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ANALYSIS OF MILITARY ASSISTANCE PROGRAM

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(6) ANALYSIS OF MILITARY ASSISTANCE PROGRAM.
PART III.
APPENDIX B.
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ATOMIC WARFARE,

(10) by W. L. Whitson, K. D. Bartino, D. K. Clark, A. D. Coop and W. B. Cottrell. [redacted]

(14) Rept. no. ORO-R-3 Pt. 3 - App. B.

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Appendix B

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FOREWORD

The paramount problems facing the US Army in maintaining and possibly defending the US and its interests in the world in the light of the probable use of atomic weapons in future warfare have been the primary causes for the ~~following~~ study under the general subject of Atomic Warfare. Included here are a total of four annexes which are entitled:

Annex 1: The Effect of Variation of Energy on Atomic Weapons Characteristics,

Annex 2: World War II Tactical Situations Analyzed with Respect to Atomic Weapons.

Annex 3: Atomic Weapons in Army Operations, and

Annex 4: Atomic Weapons in Western Europe.

An attempt has been made here to explore the relatively new and vital problem of the effect of using atomic weapons in conjunction with military ground operations. Being new, such analyses as the one presented here leave much to be desired in the character of the evidence which can be brought to bear on the subject. The analysis is predominantly qualitative but in many instances forecasts the possibility of more quantitative procedures. Despite the fact of its being preliminary in nature and subject to revision in the light of rapidly increasing evidence, this study is presented in the belief that it is possible to form some important and meaningful conclusions which will be helpful to the solutions of the more comprehensive problems of which this atomic study is an introductory part.

Attention is called to the fact that all restricted atomic energy data for which specific AEC clearance is required has been removed from this issue in order to facilitate more widespread distribution and use by military personnel. It is the intent that the remaining, published information in the following study include

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those categories of restricted data of primary significance to the Department of Defense which require wide dissemination within the armed forces. Access to the original copies containing specific restricted data may be obtained by properly authorized personnel by request through the proper official channels.

Since the original preparation of the manuscript for this report, developments in atomic weapons have transpired which serve to alter somewhat the tactical considerations set forth herein. In general, the use of high KT bombs against large industrial targets continues to be practical. However, applications of certain hitherto unavailable, small (less than 20 KT) atomic weapons against troops in the field are now possible. These weapons may require bursts near ground level. The principal novel effects of the smaller bursts would be improved geometry—that is, reduced over-kill of enemy troops and increased protection to friendly troops—and a modified relative emphasis on blast, thermal, and radiation damage. Reports discussing appropriate uses of the new weapons are forthcoming.

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Atomic Energy Act - 1946
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APPENDIX B
ATOMIC WARFARE

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Prepared by

W. L. WHITSON
K. D. BARTIMO
D. K. CLARK
A. D. COOX
W. B. COTTRELL
G. N. DONOVAN
E. S. GILFILLAN, JR.
K. C. HAFSTAD
W. B. HEINZ
N. M. SMITH, JR.
S. H. TURKEL
W. H. WELLS

21 January 1950

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21 January 1950

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Annex 2. World War II Tactical Situations Analyzed with Respect to Atomic Weapons

Annex 3. Atomic Weapons in Army Operations

Annex 4. Atomic Weapons in Western Europe

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ANNEX 1

THE EFFECT OF VARIATION OF ENERGY ON ATOMIC WEAPONS CHARACTERISTICS

Prepared by

EDWARD S. GILFILLAN, JR., SOLOMON H. TURKEL,
and WILLIAM H. WELLS

1 January 1950

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THE EFFECT OF VARIATION OF ENERGY ON ATOMIC WEAPONS CHARACTERISTICS

SUMMARY

PROBLEM

The problem is to summarize, in a form suitable for military purposes, the effects of air burst atomic weapons of up to 100 KT of TNT equivalent energy.

FACTS

Much of the large amount of information already available (see bibliography) and pertinent to the problem is neither in a suitable form nor sufficiently complete for direct application to military problems.

Consistent with an evaluation of all target systems and weapons systems, it is necessary to examine atomic bursts of all possible energies to determine the weapons and weapons systems that would be most effective.

CONCLUSIONS

The most effective use of an air burst atomic weapon of up to 100 KT energy against personnel is to detonate it at an altitude optimizing the blast area.

At the above altitudes, the radii of the areas of corresponding damage from blast overpressures and thermal radiation are increased by a factor around 1.7 and the areas by a factor of 3 as the energy of the burst is increased from 20 to 100 KT.

As the energy of the burst increases, the thermal radiation, because of atmospheric attenuation as well as the inverse square law, increases only in a manner similar to the assumed increase for blast areas, i.e., approximately as the cube root of the energy for the radius.

For weapons up to 100 KT energy, atmospheric attenuation on a very hazy day can decrease the ground radius of injurious thermal radiation intensities by a factor of about 2 from the radius for that intensity on a clear day.

For energies up to 100 KT and detonations at altitudes optimized for blast, the radius for 50 percent lethal thermal radiation intensity for personnel in the open exceeds, even under the most adverse atmospheric conditions considered, the radius for 50 percent lethal (delayed) gamma radiation intensity from bursts optimizing the nuclear effect.

For all energies, the areas of nuclear radiation contamination will be a maximum when the altitude of bursts is held to a minimum. For this condition the radius for 50 percent lethal (delayed) intensity increases from 1,260 to 1,700 yards or a ratio of 1.35 as the energy is increased from 20 to 100 KT.

For all energies between 5 and 100 KT, the radius for a given intensity of thermal radiation, determined by optimizing the height of burst for blast, differs less than 10 percent from the radius for a constant 600-yard height of burst. The radius of any thermal radiation intensity area increases approximately as the cube root of the energy.

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THE EFFECT OF VARIATION OF ENERGY ON ATOMIC WEAPONS CHARACTERISTICS

INTRODUCTION

Consistent with the development of better atomic weapons, it is necessary to summarize the effects resulting from the use of such weapons against personnel, structures, terrain, et cetera, and to show how these effects will vary with bomb energy and certain environmental conditions. The significance of these variations to the military tactical use of atomic weapons will be of paramount importance to future planning.

Some material of this type already exists in a few analyses and compilations[1 2 3] of weapons effects and variations of weapon energy. In general, they form the best authoritative judgments of atomic phenomena in existence. However, for military use in field conditions and field army planning, this information has not been made sufficiently practicable to apply to military troops in various types of tactical situations. The task undertaken here is to estimate and present the phenomena and effects of the explosion in the air of atomic weapons up to 100 KT of TNT equivalent in such a way that the military effects and implications may be appraised. The following analysis and discussion attempts to summarize weapons effects from this point of view. The information from the known sources is used together with additional original treatments, and applied to some specific military tactical situations.

In general, the effects resulting from the explosion of an atomic weapon are of three types; namely, blast, thermal radiation, and nuclear radiation. The overlap considerably with respect to the damage caused, the numbers of casualties produced, and the total area affected. From blast, in particular, considerable secondary damage and casualties are caused by fires, flying debris, falling buildings, et cetera, which frequently transcend any direct results from primary blast. It is possible to minimize or maximize any one of the three weapons effects, in preference to the other two, by varying the height of burst. The magnitude of the effects will vary according to whether the weapon is exploded high in the air, on or near the ground, underground or underwater. In this analysis we shall consider only the air burst weapon as it is the only proven atomic weapon. Furthermore, it lends itself well to a systematization of weapons effects and a scaling with weapon energy. Since nearly all weapons so far used have been exploded in this manner, there is an appreciable amount of recorded data. Consideration will be given to the factors involved in other type bursts in subsequent analyses. In general, the present analysis will be restricted to weapons up to 100 KT although some discussion and data will be given to weapons above this. For the most part, weapons above 100 KT energy will possess somewhat different characteristics of design, and their effects will be treated elsewhere.

The height at which an atomic weapon is exploded will play an important part in determining the effects and the damage area. It will vary with the particular effect and its magnitude desired. The following analysis will include calculations concerning optimum heights to be used in various situations.

In general, for an air burst, approximately 89 percent of the total energy released will be instantaneous; 11 percent of the total will come from the fission products, delayed for periods varying from seconds to years as the

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[1] *Weapons Effects Handbook*, 1949 Edition, AEC. To be declassified as "The Effects of Atomic Weapons," probably August 1950 and issued by the Superintendent of Documents, Government Printing Office.

[2] *Technical Study of Destructive Areas*, LA-694, 4 August 1948

[3] *Employment of Atomic Weapons Against Various Types of Targets*, SB/15-TS-1616-1A, 29 July 1949.

fission products decay. Of the total released energy 30 percent or about one-third of the total instantaneous release will go into thermal energy, 53 percent or a little less than two-thirds of the total instantaneous release will go into blast energy, and about 6 percent into nuclear radiation equally divided between gamma rays and neutrons. The total energy released from a 20 KT weapon is equal to 8.4×10^{20} ergs or 2×10^{13} calories.

NUCLEAR RADIATION

Approximately 6 percent of the total energy is instantaneously released from the explosion of an atomic weapon up to 100 KT in the form of nuclear radiations, principally neutrons and gamma rays. For all practical purposes, neutrons may be eliminated from consideration since the attenuation of neutrons by air is fairly great and, hence, neutrons will be effective only in some cases and only very close to ground zero, where the other effects are lethal many times over. For the 20 KT weapon the neutrons are lethal to only 700 yards slant range or less than 450 yards from ground zero. For energies higher than 20 KT the neutron intensity at a given distance will be proportional to the first power of the energy but still of no practical importance in comparison to the other effects.

The gamma component of the nuclear radiation is effective over a much larger area. Figure 1 shows the curve [4] of the total gamma ray intensity times the slant distance squared as a function of the slant distance, obtained from data from the Bikini Able burst. Since the attenuation of gamma ray intensity is exponential, this curve is nearly a straight line from which a linear equation is easily obtained. Figure 1 also shows the gamma radiation intensity in roentgens as a function of the slant distance from burst derived from the above data. Solutions of this equation were obtained to give the slant distances and, hence, the horizontal distances in yards from ground zero where personnel will receive a total accumulated dose of 400 roentgens, which is the dose at which 50 percent of personnel will die within six weeks, and an accumulated dose of 100 roentgens, which is the dose at which nearly all personnel will experience temporary sickness of varying degrees but no deaths. The heights of burst were optimized for maximum blast effects, using 600 yards for 20 KT and scaling according to the cube root of the KT energy. (Details of this calculation may be seen in Enclosure A.) Table I and Figure 2 show the horizontal distances as a function of the KT energy.

With reference to Table I it is seen that for a 200 KT weapon exploded at the calculated optimum blast height of 1,292 yards the range in the open for the median lethal gamma ray dose of 400 roentgens is about 1,500 yards, and the range for the sickness dose of 100 roentgens is about 2,000 yards. With increasing values of bomb energy the corresponding height of burst for optimum blast increases more rapidly than does the effective range of the gamma radiation associated with a bomb. Table I indicates that if blast damage alone is chosen as the criterion of burst height, then for bombs of weight greater than 1,500 KT—which would be exploded at heights above 2,560 yards—the 400-roentgen level of gamma ray dose occurs in the air above the surface of the earth, and the dose anywhere on the ground is less than 400 roentgens. Similarly, for bombs larger than 2,900 KT the radiation dose on the ground is less than 100 roentgens. However, beyond 100 KT and the corresponding calculated optimum height of 1,026 yards, atmospheric conditions and a change in weapon characteristics must be considered, and these will be treated elsewhere.

For personnel in the open, such as troops in the field where there are no or very few structures, blast has little secondary or primary effect since the total overpressures produced by an air burst at the heights given are well below the amount estimated necessary to have primary lethal effect on man. Hence, in this situation it is more desirable to place the weapon at heights such that the horizontal range for gamma radiation will be a maximum. In general, this optimum height will approach the ground since at this altitude the burst will spread the radiation over the ground with maximum effect and range.

[4] "Scientific Director's Report of Atomic Weapons Tests." Sandstone, *Handbook of Nuclear Explosions*, Volume III, 6 May 1949.

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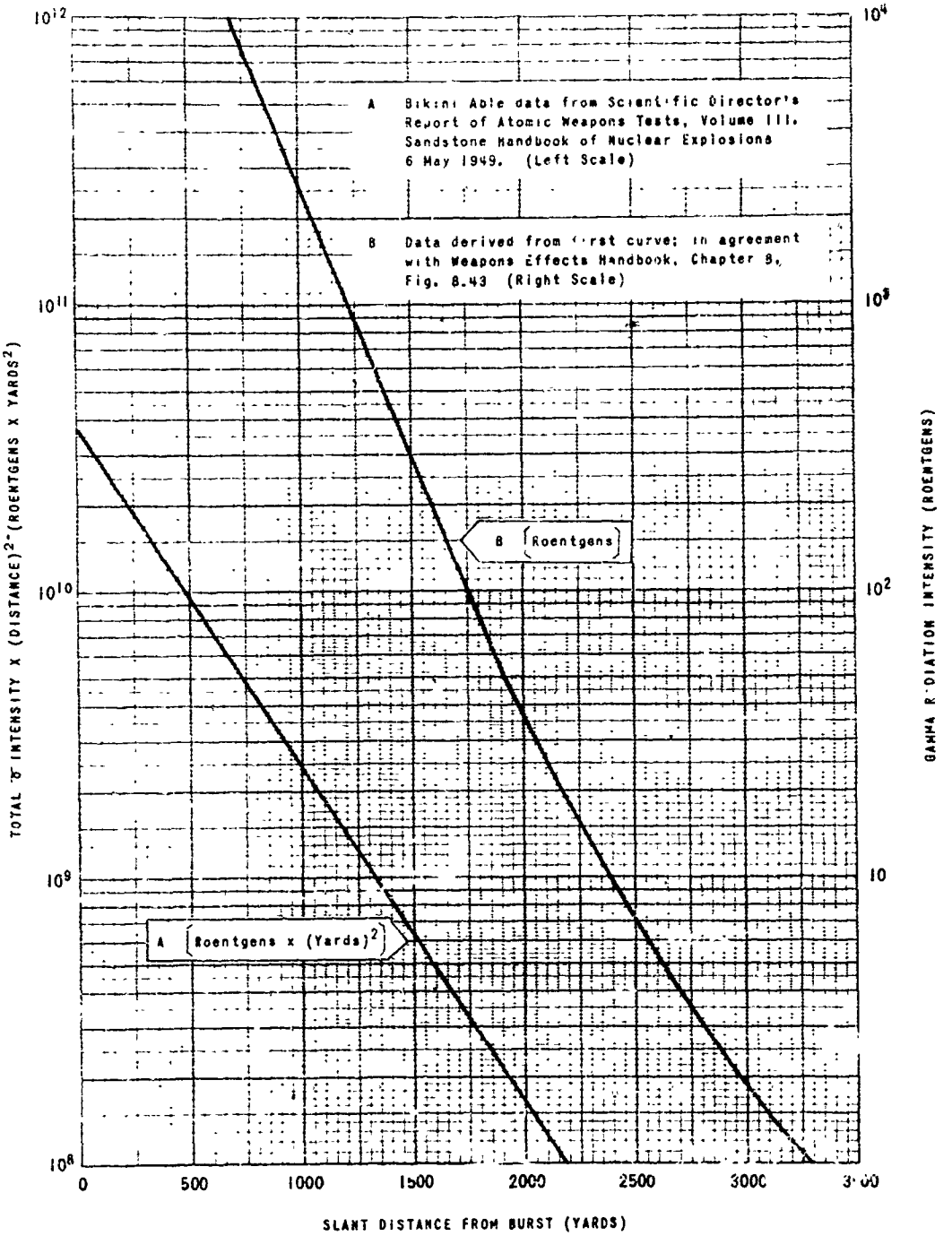

Figure 1—Gamma Radiation Intensity in Roentgens from the Explosion of a 20 KT Atomic Weapon in the Air as a Function of the Slant Distance in Yards from the Burst

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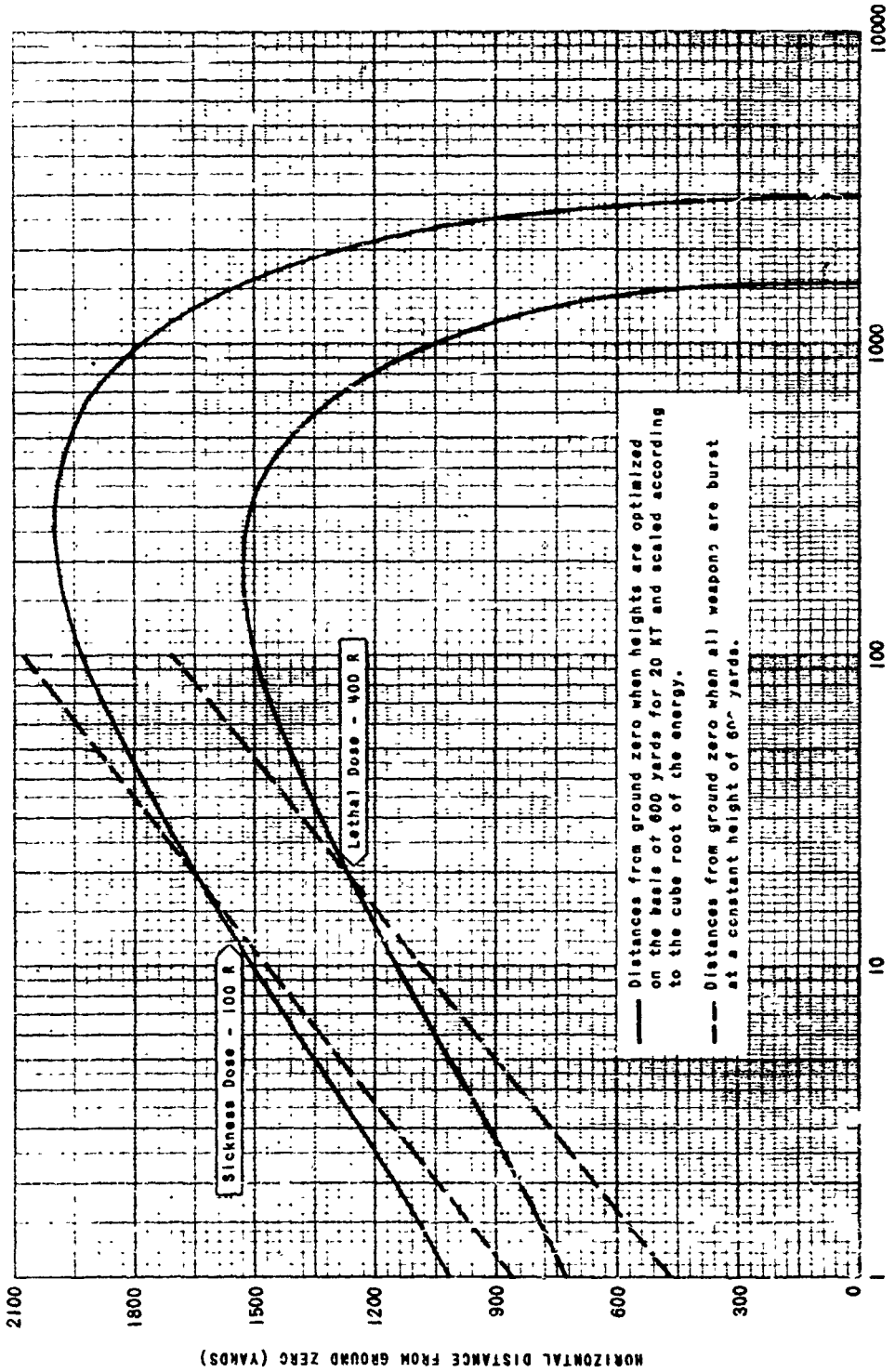

Figure 2.—Distances at which Lethal and Sickness Doses of Gamma Radiation will be Received from Atomic Weapons of Various Energies Exploded in the Air at Heights Varying as the Cube Root of the Energy

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TABLE I
VARIATION OF THE DISTANCES FROM AN ATOMIC BOMB OF VARIOUS ENERGIES EXPLODED IN THE AIR AT HEIGHTS SCALED ACCORDING TO THE CUBE ROOT OF THE ENERGY TO RECEIVE A LETHAL OR SICKNESS DOSE OF GAMMA RADIATION

ENERGY (KT)	HEIGHT OF BURST	SLANT DISTANCE (YD)		HORIZONTAL DISTANCE FROM GROUND ZERO (YD)	
	$600\left(\frac{KT}{20}\right)^{1/3}$ yd	(For 400 R)	(For 100 R)	(For 400 R)	(For 100 R)
1	221	763	1,045	730	1,018
2	278	900	1,200	856	1,167
5	378	1,092	1,410	1,024	1,359
10	476	1,245	1,580	1,150	1,507
20	600	1,410	1,757	1,276	1,651
40	756	1,580	1,940	1,387	1,787
60	865	1,682	2,040	1,442	1,848
80	952	1,757	2,125	1,476	1,900
100	1,026	1,813	2,185	1,495	1,929
200	1,292	1,996	2,380	1,521	1,999
350	1,558	2,150	2,530	1,481	1,993
500	1,754	2,247	2,335	1,404	1,966
1,000	2,210	2,440	2,833	1,034	1,772
1,500	2,532	2,550	2,950	302	1,513
1,550	2,560	2,560	2,960	0	1,485
2,000	2,784	2,630	3,040		1,221
2,900	3,152	2,740	3,152		0
10^4	4,762	3,100	3,520		
10^5	10,260	3,800	4,225		
10^6	22,104	4,500	4,950		
10^7	47,622	5,290	5,690		

The detonation height of 600 yards is considered practical against men in the open in order to clear all trees, small structures, hills, trenches, et cetera. For this height a median lethal dose of 400 roentgens and a sickness dose of 100 roentgens will be received up to ground ranges as shown in Table II.

Where a tactical military situation is of short duration, of the order of a few hours or less, it is necessary to remember that the gamma radiation doses used in Table II do not imply the certain *immediate* incapacitation of the individual. The 400 roentgens dosage will make most men sick to varying degrees of intensity and for varying periods of time, with symptoms of radiation sickness such as nausea, vomiting, anorexia, malaise, epilation, fever, diarrhea, severe thirst, delirium, decrease in white and red blood cell

TABLE II
VARIATION OF DISTANCE FROM AN ATOMIC BOMB OF VARIOUS ENERGIES EXPLODED IN THE AIR AT A HEIGHT OF 600 YARDS TO RECEIVE A LETHAL OR SICKNESS DOSE OF GAMMA RADIATION

ENERGY (KT)	HORIZONTAL DISTANCE FROM GROUND ZERO (YD)	
	(For 400 R)	(For 100 R)
1	469	856
2	671	1,039
5	912	1,276
10	1,091	1,461
20	1,276	1,651
40	1,461	1,845
60	1,571	1,950
80	1,651	2,038
100	1,710	2,101

counts, petechiae (small hemorrhage under skin); and in addition, 50 percent of all men so exposed will probably die within six weeks. Many of the men made sick will be incapacitated for short periods of time and, conceivably, will still be able to participate effectively in the immediate tactical situation. There may also be some delayed effects which would not incapacitate some individuals until later on. A dose of 100 roentgens will produce many of the above symptoms but in considerably milder form and probably will not incapacitate more than a few individuals temporarily and will not seriously affect the tactical situation shown in Table II. No deaths will occur from this single cause.

A gamma radiation dosage sufficient to kill a man within an hour, or to take him out of action completely within an hour with very probably death within a few hours, is estimated to be of the order of 1,000 to 4,000 roentgens. Doses of this magnitude may be received very close to ground zero, but thermal and secondary blast effects will be even more effective in killing a man so close to the hypocenter.

Comparison of the data in Table II with those in Table I indicates that up to 100 KT approximately the same gamma radiation casualty radii will be produced by all weapons burst at a fixed height of approximately 600 yards as by the weapons burst at optimum heights to maximize the blast effect which

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increases as the cube root of the KT energy. Despite the fact that immediate casualties are not caused by gamma radiation except close to the hypocenter, it is probable that the radiation will have considerable psychological effect on troops in the vicinity of any atomic burst.

THERMAL RADIATION

It is estimated that approximately one-third of the total energy is instantaneously released from the explosion in the air of atomic weapons of energies up to 100 KT in the form of thermal radiation. This radiation travels at the velocity of light and is in the form of a pulse of very great intensity and whose duration is extremely short. An initial very high peak occurs in less than one millisecond after the burst, decreasing to a minimum in about 0.1 second after the burst. This is followed by a second smaller peak between 0.2–0.3 seconds after the burst. After this second maximum, the "ball of fire" gradually cools by radiation and expansion over a period of several seconds. It is during the phase after the minimum that most of the radiant energy from the bomb appears. Despite considerable absorption by the atmosphere, sufficient intensities of thermal radiation are transmitted to kill all personnel in the open to very great distances.

A threshold value for the sensation of pain from thermal radiation is given[5] as 0.1–1.0 calorie per sq cm when received in three seconds. Additional information[6] for a 20 KT burst indicates that ordinary clothing will burn, producing extensive body burns sufficient to cause death up to distances of 2,500 yards from ground zero. It will be seen from the following analysis and Figure 3 that at this distance the radiation intensity will be 6.5 calories per square centimeter. It has, therefore, been assumed that thermal radiation of intensities as low as 6.5 calories per sq cm received within two seconds will be sufficient to immediately kill more than half of all individuals in dry herringbone twill uniforms receiving such a dose.

It has been estimated that thermal radiation of intensities as low as 4.0 calories per sq cm within two seconds may be sufficient to cause burns immediately hospitalizing or incapacitating more than half of all individuals in dry herringbone twill uniforms receiving such a dose. It is known, however, that special clothing can withstand these radiant energies and that light structures and intervening objects can very effectively reduce the intensity of thermal radiation incident to an individual so that the resultant thermal effects may be appreciably less than indicated.

Atmospheric absorption contributes significantly to the attenuation of thermal radiation from an atomic burst. Absorption losses may be conveniently expressed by a coefficient which is estimated in terms of visibility as shown in Table III.

TABLE III
LIMITS OF VISIBILITY AND ATMOSPHERIC ATTENUATION COEFFICIENTS FOR DIFFERENT ATMOSPHERIC CONDITIONS

ATMOSPHERIC CONDITIONS	LIMITS OF VISIBILITY	
	(Miles)	(Per KM)
Clear	10–12–20	0.2
Hazy	4–6–8	0.4
Very Hazy	1–2.5–4	1.0

The figures under Limits of Visibility include the upper and lower limits as well as the mean value.

Table IV gives the classes of injuries which will be incurred by personnel in selected uniforms for various values of thermal radiation. The figures given for thermal radiation include the upper and lower limits as well as the mean value for a given type casualty.

The total energy from a 20 KT atomic weapon explosion is 8.4×10^{20} ergs, of which one-third is in the form of thermal radiation when the height of burst is below the haze level. Passage through the atmosphere will attenuate this radiation by exponential absorption and by the inverse square of the traversed distance. Hence, the intensity of this radiation will vary according to the equation

$$I = I_0 \frac{e^{-\alpha r}}{r^2}$$

[5] *Atomic Bomb Handbook*, April 1, 1949 Series, Chapter 10. Superseded by footnote 1.

[6] *The Inflammability of Combat Suit Materials with Special Reference to Atomic Warfare*, AORG Report No. 9/49.

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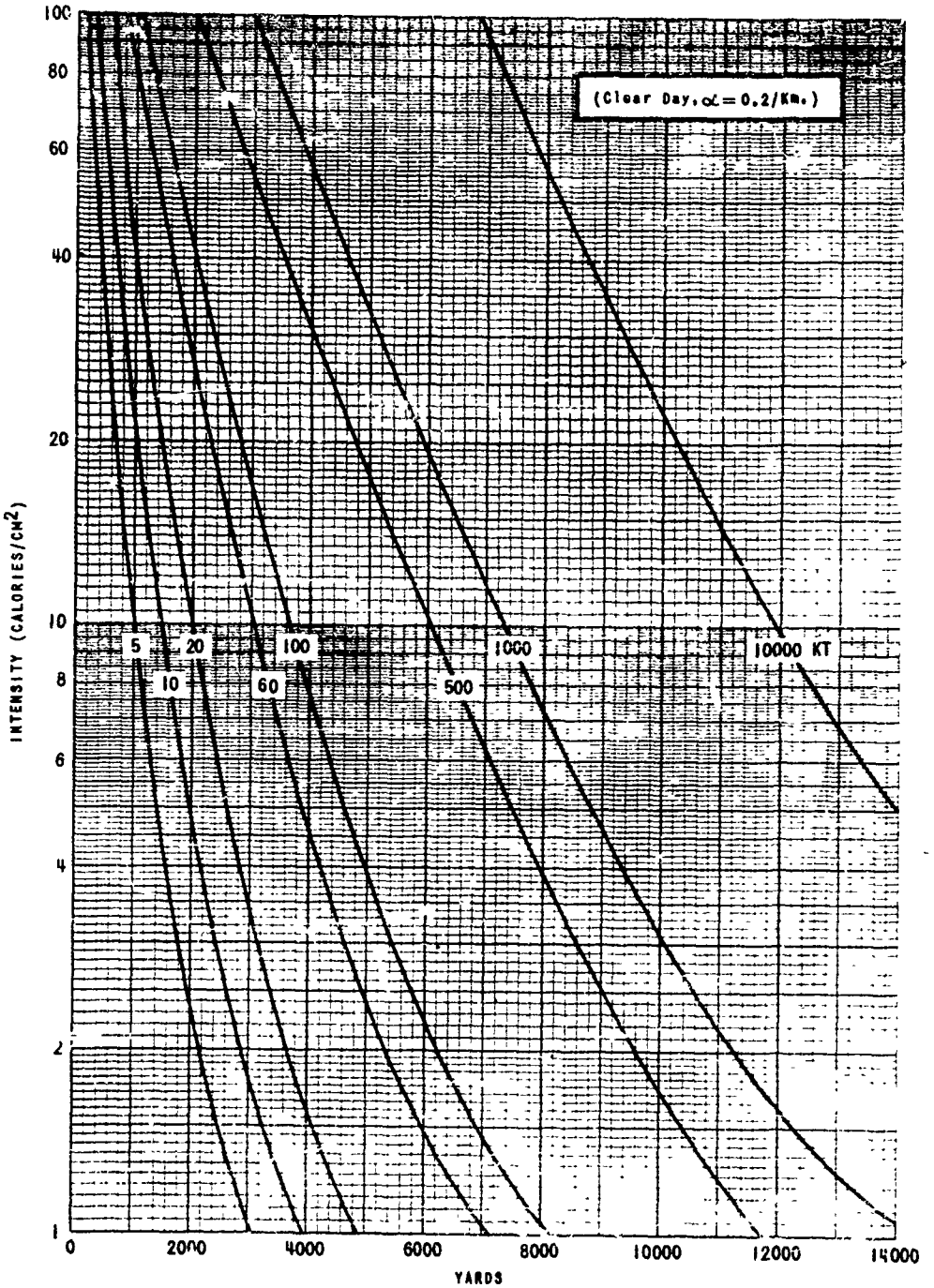

Figure 3.—Thermal Radiation Intensity as a Function of Horizontal Distance from Ground Zero for Atomic Weapons of Various KT Energies Exploded at Heights Scaled by the Cube Root of the Energy

where I_0 is the intensity obtained from the weapon energy stated previously, α is the absorption coefficient for the atmosphere, and r is the slant distance from the burst to the ground.

By "special" uniform is meant one which is designed specifically to withstand thermal radiation. It will be made of materials of special type and of sufficient thickness so that it will not burst into flame but will only char without burning, thus protecting the skin underneath. It should be made so that in such cases it could be easily discarded. It is believed that practical uniforms can be designed to protect troops from instantaneous heat intensities as great as 100 calories per square centimeter. The limiting factor is not the rate but, rather, the total energy which can be absorbed by the uniform without heating the interior to dangerous temperatures.

"Ordinary" uniforms will normally include varying proportions of cotton and wool and, therefore, the thermal energy values of both classifications A and B in Table IV must be taken into consideration.

Solutions of the preceding equations were obtained to determine the horizontal distances from ground zero at which various degrees of burn damage are induced. This is done for various energies, the height of burst being optimized for maximum blast area, and for the three types of atmospheric absorption conditions described in Table III. Figures 3–8 present the results of these calculations. Details of these calculations are given in Enclosure B.

Table V summarizes the information in Figures 3–8 for the condition that the troops are wearing dry herringbone twill uniforms. The horizontal distance in yards, for both lethal and incapacitating amounts of thermal radiation, are given for the three atmospheric conditions. The height of the burst is scaled to optimize the blast area.

TABLE IV
ESTIMATED THERMAL RADIATION REQUIRED TO PRODUCE CERTAIN PERCENTAGES OF CASUALTIES TO TROOPS IN THE OPEN IN VARIOUS TYPES OF CLOTHING

CLASSIFICATION OF INJURY AND UNIFORM	THERMAL RADIATION (CALORIES/CM²)
1—A	4–6–5–10
1—B	7–11–16
1—C	50–100–200
2—A	2–4–6
2—B	3–5–7
2—C	67–75–150
3—A	1–5–2–3–5
3—B	1–5–2–3–5
3—C	37–50–67

The classification of uniform and injury have the following significance:

1. Approximately 70 percent fatalities.
2. Approximately 70 percent hospitalization.
3. Approximately 70 percent uninjured.

A. Dry herringbone twills.
B. Wool OD.
C. Special uniform

TABLE V
VARIATION OF THE DISTANCE FROM AN ATOMIC BOMB OF VARIOUS ENERGIES EXPLODED IN THE AIR UNDER VARYING ATMOSPHERIC CONDITIONS AT HEIGHTS SCALED ACCORDING TO THE CUBE ROOT OF THE ENERGY TO RECEIVE LETHAL OR INCAPACITATING BURNS

HEIGHT OF BURST (YARDS)	ENERGY (KT)	HORIZONTAL DISTANCES FROM GROUND ZERO (YARDS)					
		Lethal Effects Thermal (6.5 cal/cm²) (approximately 70% immediate deaths)			Incapacitating Effects Thermal (4 cal/cm²) (approximately 70% out of action)		
		Clear	Hazy	Very Hazy	Clear	Hazy	Very Hazy
378	5	1,300	1,150	850	1,600	1,400	1,050
476	10	1,800	1,500	1,050	2,200	1,900	1,200
600	20	2,400	2,000	1,280	2,900	2,300	1,520
865	60	3,500	2,900	1,600	4,200	3,200	1,900
1,026	100	4,200	3,200	1,900	5,000	3,800	2,170
1,754	500	6,900	4,800	2,460	8,000	5,600	3,250
2,210	1,000	8,300	5,500		9,400	6,300	
4,762	10,000	13,200	7,900		15,000	8,800	

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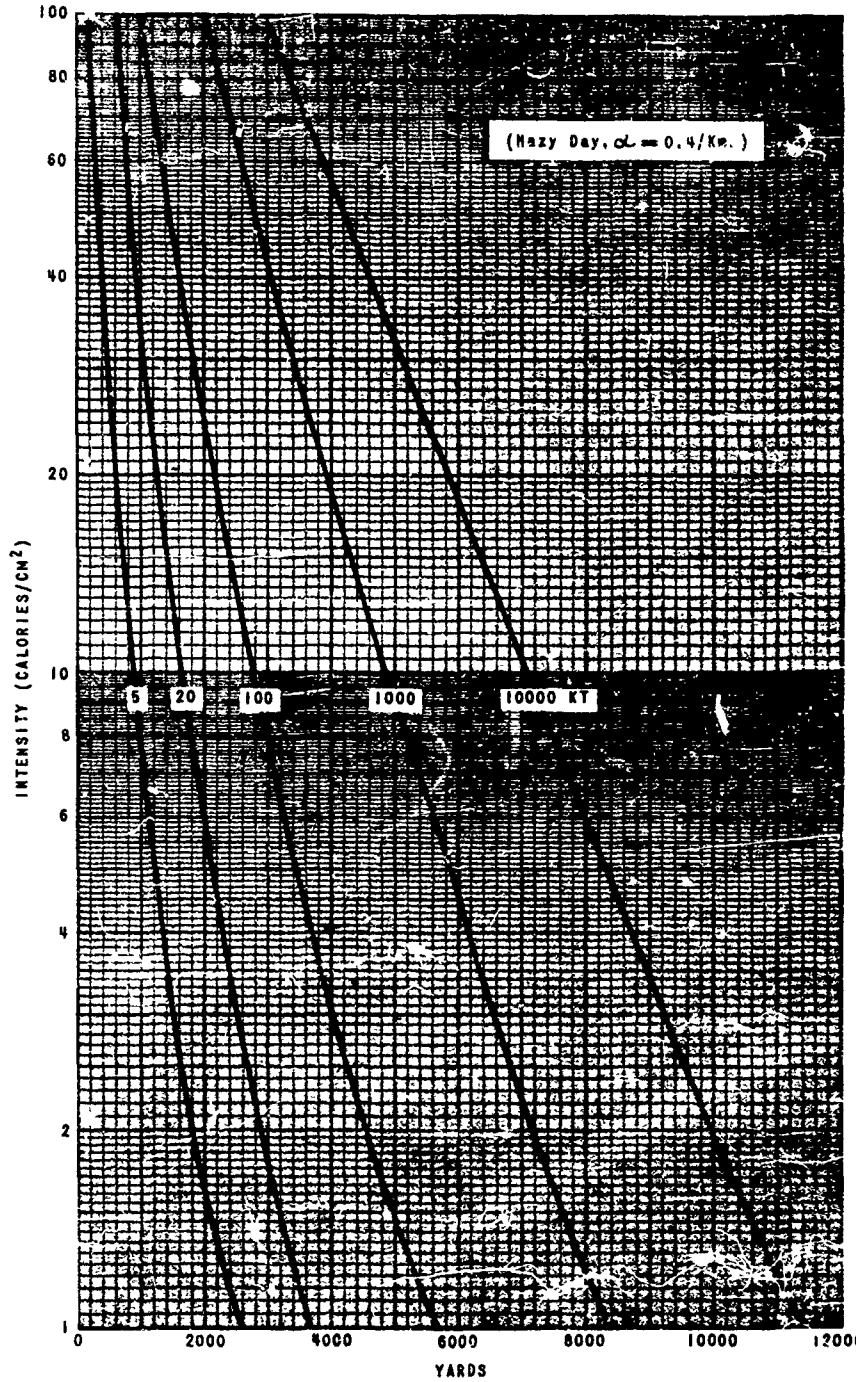

Figure 4.—Thermal Radiation Intensity as a Function of Horizontal Distance from Ground Zero for Atomic Weapons of Various KT Energies Exploded at Heights Scaled by the Cube Root of the Energy

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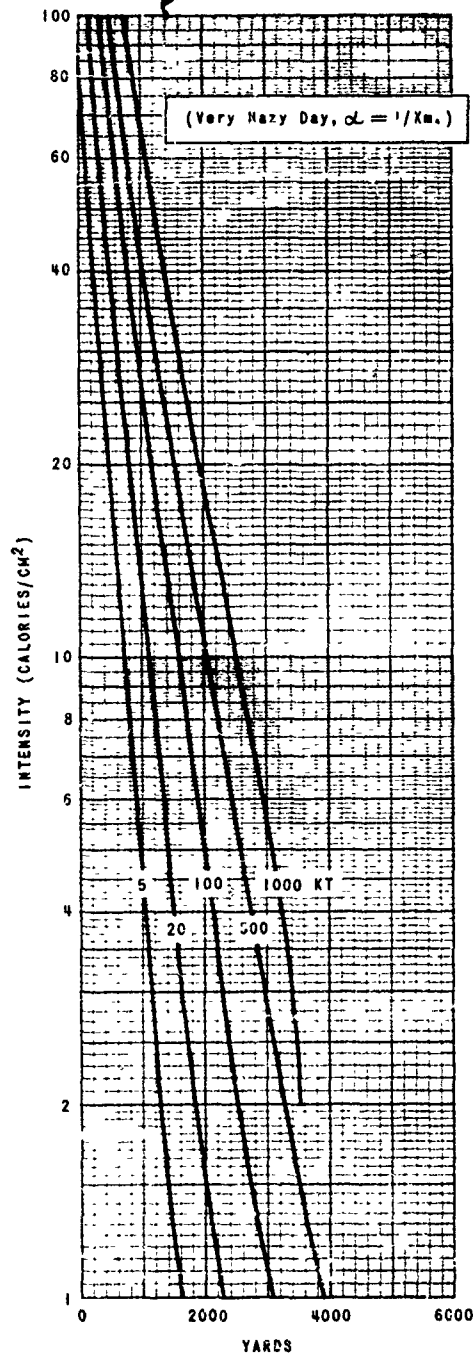

Figure 5.—Thermal Radiation Intensity as a Function of Horizontal Distance from Ground Zero for Atomic Weapons of Various KT Energies Exploded at Heights Scaled by the Cube Root of the Energy

It is readily evident from examination of these values that above 20 KT a person in the open will receive lethal doses of thermal radiation on a clear or moderately hazy day out to much greater distances than for lethal doses of gamma radiation. However, even for a very hazy day the thermal effect will be received as far or farther from ground zero than the gamma radiation effect even when the height of burst is optimized for the latter. This definitely indicates the great effectiveness of thermal radiation in producing mortality or incapacitation of personnel in the open as compared to gamma radiation. Since gamma radiation effects are generally delayed, it is further evident that the thermal radiation effects will predominate in producing the immediate casualties that will influence the tactical military situation. However, thermal radiation is much more easily absorbed by shielding objects or by special clothing protecting the individual than is gamma radiation and, therefore, may be substantially reduced by proper indoctrination and special articles of clothing. With such training and shielding it is possible that the thermal and gamma radiation effects can be made to have similar effects on the individual within approximately equal distances from ground zero. Without such shielding, thermal effects should be more effective to greater distances from ground zero than gamma radiation and, being more immediate, would have greater influence on the tactical situation.

For atomic weapons up to 100 KT energy, burst so as to maximize the thermal radiation effects for use against troops in the open, Table VI gives the horizontal distance in yards from ground zero for both lethal and incapacitating doses of thermal radiation. It is assumed that there will be no or very few structures so that secondary blast effects would be small, and a practical height of burst of 600 yards, which is sufficient to clear all buildings, trees, and hills, is employed.

Comparison of the data in Tables V and VI shows again that only a small difference in the ground radii results from using 600 yards as the fixed height of burst of all weapons up to 100 KT instead of the heights scaled according to the cube root of the KT energy.

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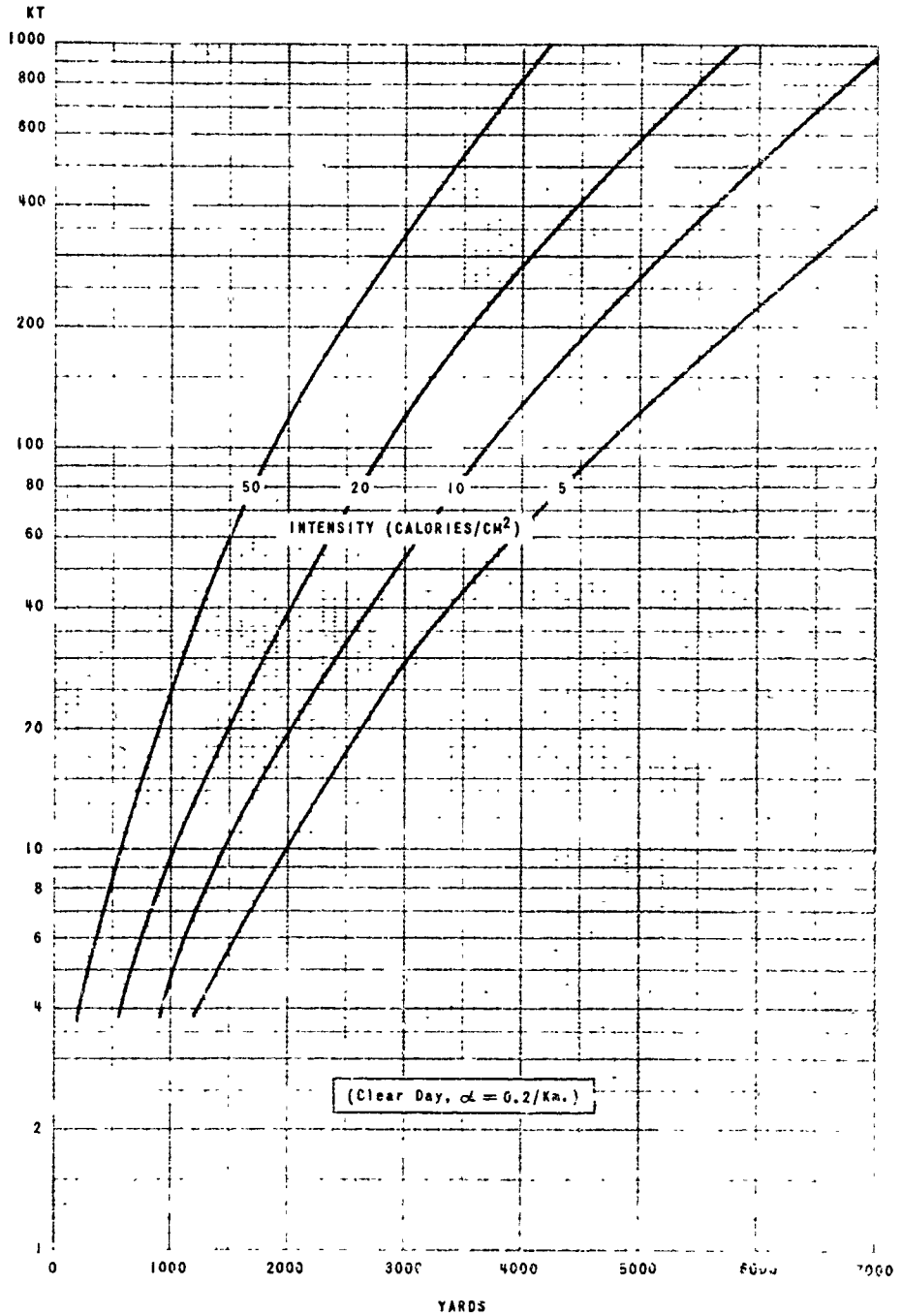

Figure 6.—Horizontal Distance from Ground Zero as a Function of KT Energy of Atomic Weapons Exploded at Heights Scaled by the Cube Root of the Energy for Various Thermal Radiation Intensities

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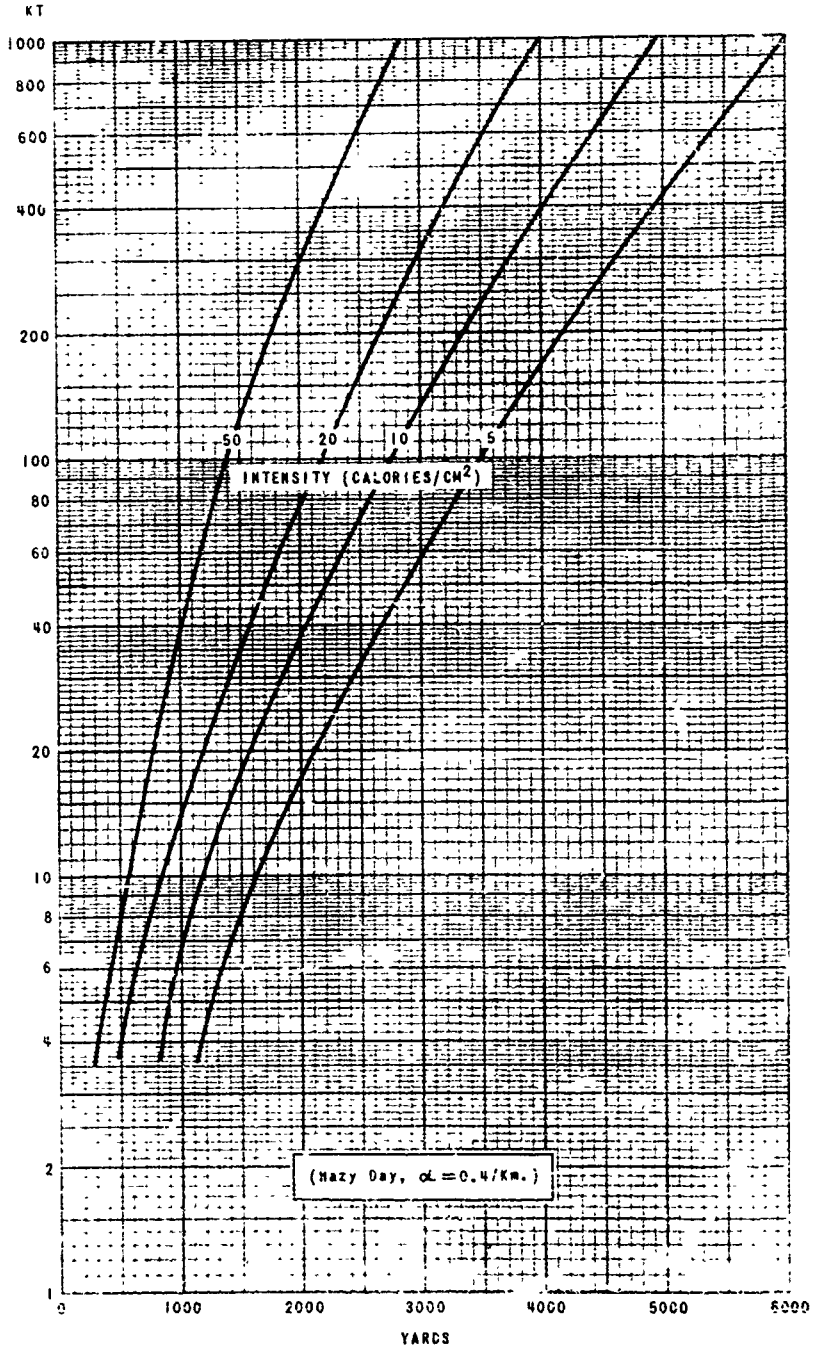

Figure 7.—Horizontal Distance from Ground Zero as a Function of KT Energy of Atomic Weapons Exploded at Heights Scaled by the Cube Root of the Energy for Various Thermal Radiation Intensities

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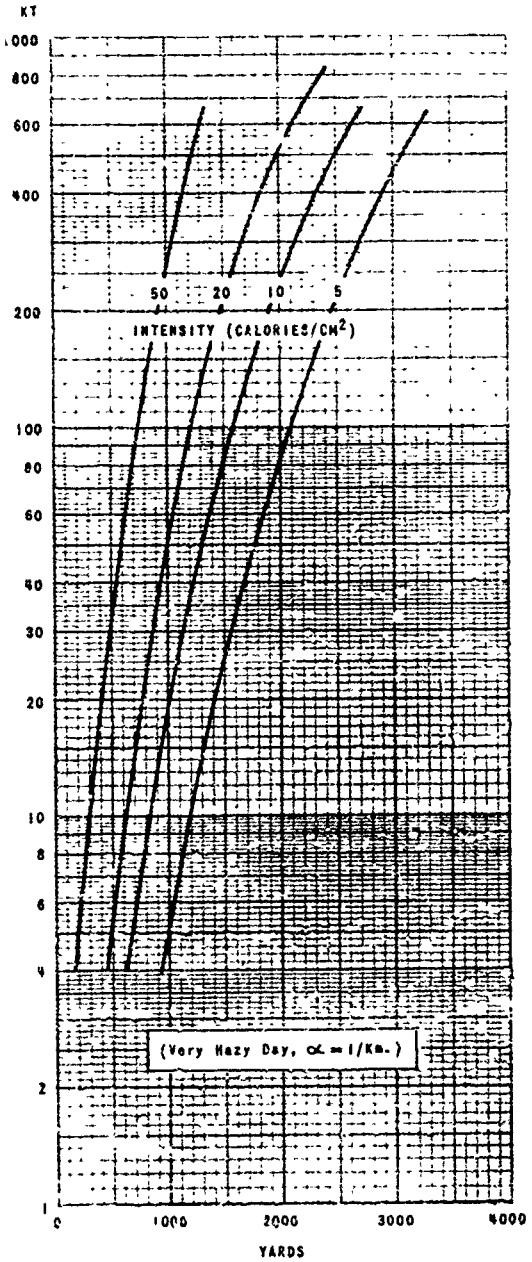

Figure 8.—Horizontal Distance from Ground Zero as a Function of KT Energy of Atomic Weapons Exploded at Heights Scaled by the Cube Root of the Energy for Various Thermal Radiation Intensities

In the foregoing analysis for gamma and thermal radiation, the tables have included values for weapons above 100 KT, using the same scaling as for weapons below 100 KT. This data becomes increasingly less valid as the energy is so increased and the heights are correspondingly increased, since it has been estimated that the weapons above 100 KT may release increasing proportions of thermal energy and decreasing amounts of blast and nuclear radiation. Furthermore, these weapons will generally have different characteristics arising from differences in design or nuclear components. Above the height of about 3,000 feet, scaling must also take into consideration the atmospheric density. This entire problem of weapon effects for weapons above 100 KT will be treated in more detail elsewhere.

BLAST

It is believed that approximately 60 percent of the total energy instantaneously released by the explosion in the air of atomic weapons up to 100 KT energy will be in the form of blast energy. This blast produces such high overpressures that it becomes the most effective agent for incurring destruction of structures to a very great distance from ground zero, and an important agent in producing casualties from the secondary effects of blast such as falling buildings, flying debris, fires, et cetera. In general, it has been estimated that an overpressure of approximately 400 psi would be necessary to kill a man by the action of the primary blast wave. Since the magnitude of the overpressures from the 20 KT weapon burst in the air is well below this at ground zero, it is obvious that blast is unimportant for producing primary casualties among personnel in the open or troops in the field devoid of structures. In such situations secondary casualties from the blast may be expected although the nuclear and thermal effects are more effective in producing casualties

In cases where structures exist, the overpressures necessary to destroy them directly and to produce other secondary hazards are appreciably lower than those required to kill an individual Based upon information furnished by the Physical Vulnerability Section,

TABLE VI

VARIATION OF THE DISTANCE FROM AN ATOMIC BOMB OF VARIOUS ENERGIES EXPLODED IN THE AIR UNDER VARYING ATMOSPHERIC CONDITIONS AT A HEIGHT OF 600 YARDS TO RECEIVE LETHAL OR INCAPACITATING BURNS

ENERGY (KT)	HORIZONTAL DISTANCE FROM GROUND ZERO (YARDS)					
	Lethal (6.5 cal/cm²)			Incapacitating (4.0 cal/cm²)		
	Clear	Hazy	Very Hazy	Clear	Hazy	Very Hazy
5	1,212	1,052	920	1,531	1,321	1,041
10	1,765	1,454		2,150	1,862	
20	2,406	2,000	1,280	2,900	2,300	1,520
60	3,550	2,964		4,240	3,260	
100	4,280	3,308	1,655	5,07[illegible]	3,886	2,420

Strategic Vulnerability Branch, DI/USAF/AFOIN, Table VII gives estimates of damage to structures of various types in terms of the incident overpressures required.

Figure 9 gives the distance from ground zero to the designated overpressure for a 20 KT weapon exploded at a height of 600 yards.

TABLE VII

REQUIRED PEAK BLAST OVERPRESSURES PRODUCED BY AN ATOMIC BOMB EXPLODED IN THE AIR TO CAUSE VARIOUS ESTIMATED DAMAGES TO STRUCTURES OF VARIOUS TYPES

OVERPRESSURE (PSI)	DAMAGE
28	Half of all reinforced concrete buildings so badly damaged as not to be worth repairing. This implies failure of main structural members and considerable distortion of the building.
12	Half of all heavy steel frame buildings so heavily damaged as not to be worth repairing.
8	Half of all light steel frame buildings so heavily damaged as not to be worth repairing.
6	Half of all bearing walls of buildings so heavily damaged as not to be worth repairing.
4	Half of all wooden-frame industrial type buildings so heavily damaged as not to be worth repairing. More than half of all trees in a medium dense forest knocked down.
1.5	Half of all parked aircraft so heavily damaged to their airframes as to require major repairs before flying again.
0.3	Extreme limit for damage to parked aircraft. No aircraft outside this limit prevented from flying.

Because of phenomena associated with the reflection of shock waves from a surface, the damage area from blast does not maximize at the same height of burst for different overpressures. In Table VIII the values of heights of burst to maximize the area subjected to specific overpressures from a 1 KT bomb were obtained from LA-743R.[7] The damage radius of each overpressure is also given.

Heights of burst and radii of damage as functions of energy release were then computed by multiplying the heights of burst given in Table VIII by the cube root of the energy release in kilotons which is the assumed scaling factor for blast. Figure 10 gives the optimum heights at which various KT energy atomic weapons up to 100 KT should be exploded in order to produce the maximum damage area for each overpressure and within which the overpressure will be equal to or greater than the given values.

Figure 11 gives the maximum damage distance from ground zero in yards within which the overpressure is a given amount or higher for the various KT energy weapons exploded at the optimized heights for each overpressure as shown in Table VIII. Figure 12 gives the damage areas within which the overpressure is a given amount or higher for various KT energy atomic weapons exploded at heights optimized for each overpressure as in Figure 10.

[7] *Height of Burst of Atomic Bomb*, LA-743R, pp. 31, 3 August 1948.

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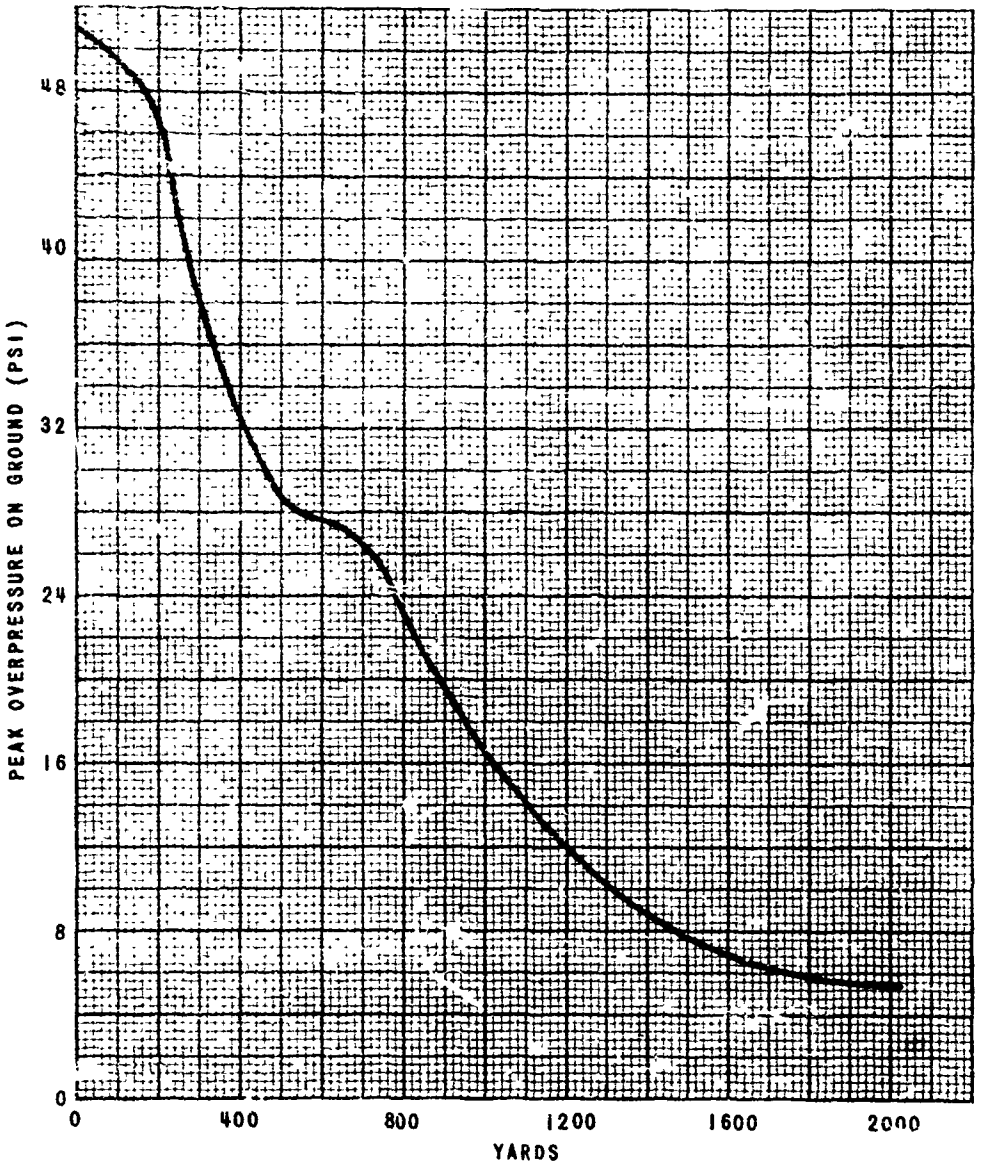

Figure 9—Peak Overpressure at Various Distances from Ground Zero from a 20 KT Atomic Weapon Exploded at a Height of 600 Yards (from *Weapons Effects Handbook*, Chapter 3, Figure 3.64)

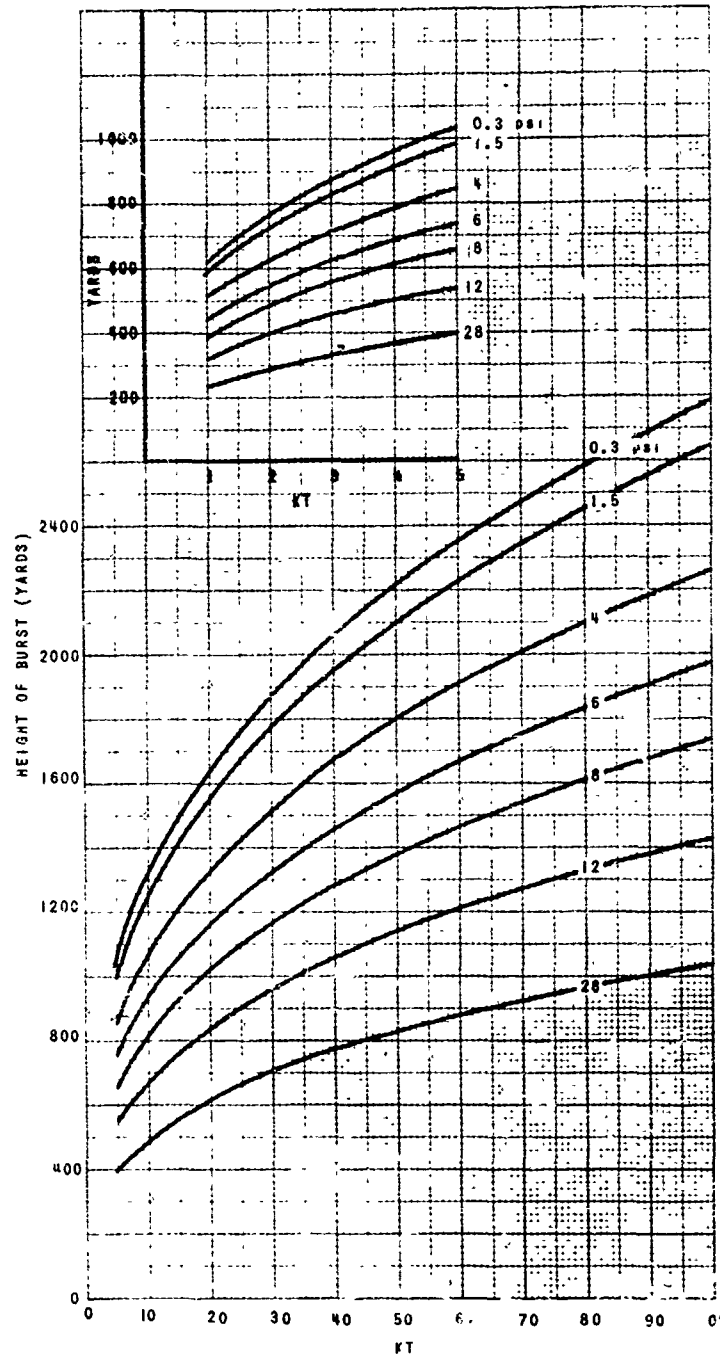

Figure 10.--Optimum Height for a Given KT Energy Weapon Exploded to Produce the Maximum Damage Area within which the Overpressure is a Given Amount or Higher (based on data from LA 743-R)

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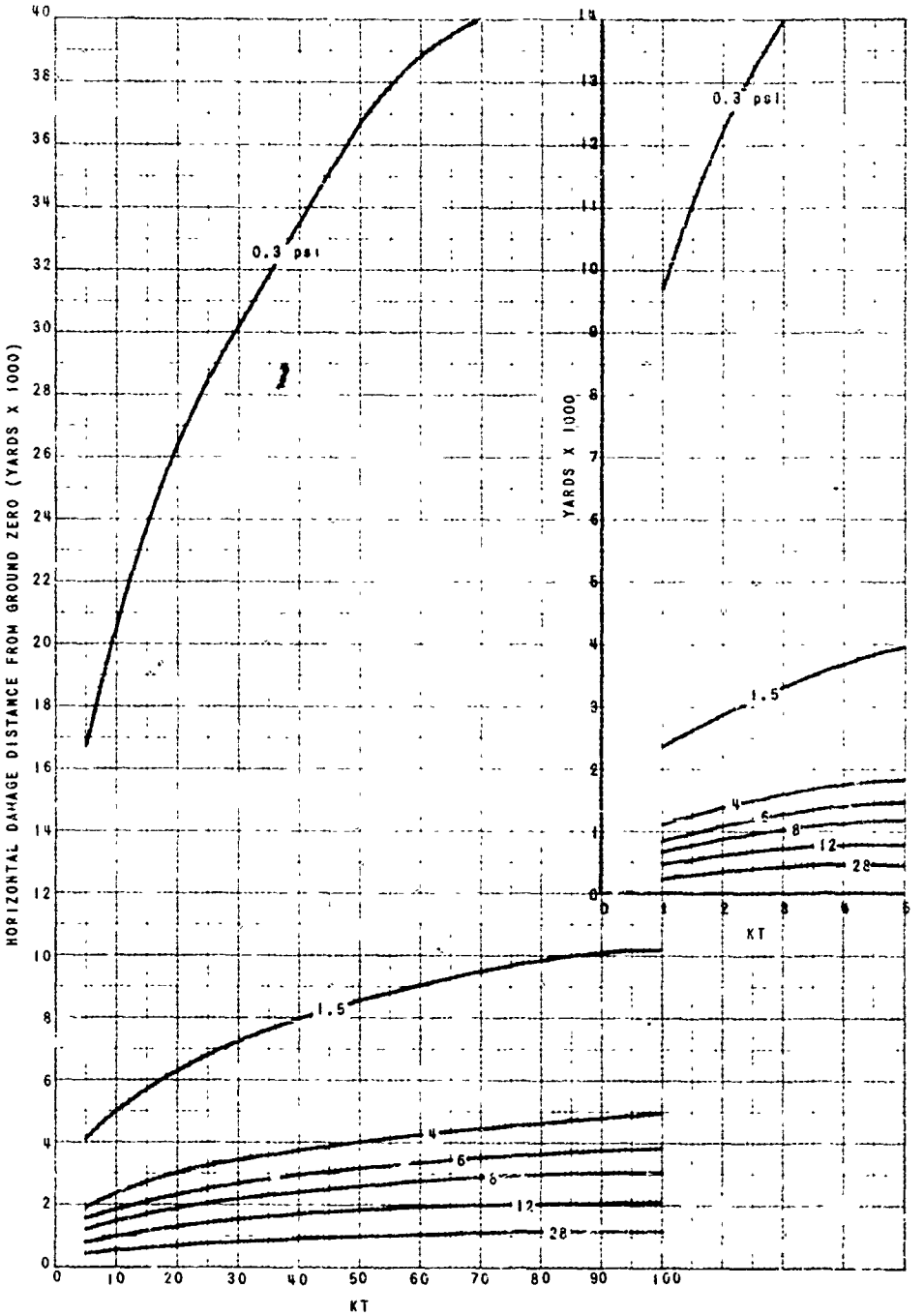

Figure 11.—Maximum Damage Distance from Ground Zero within which the Overpressure is a Given Amount or Higher for Various KT Energy Atomic Weapons Exploded at Heights Optimized as Shown in Figure 10

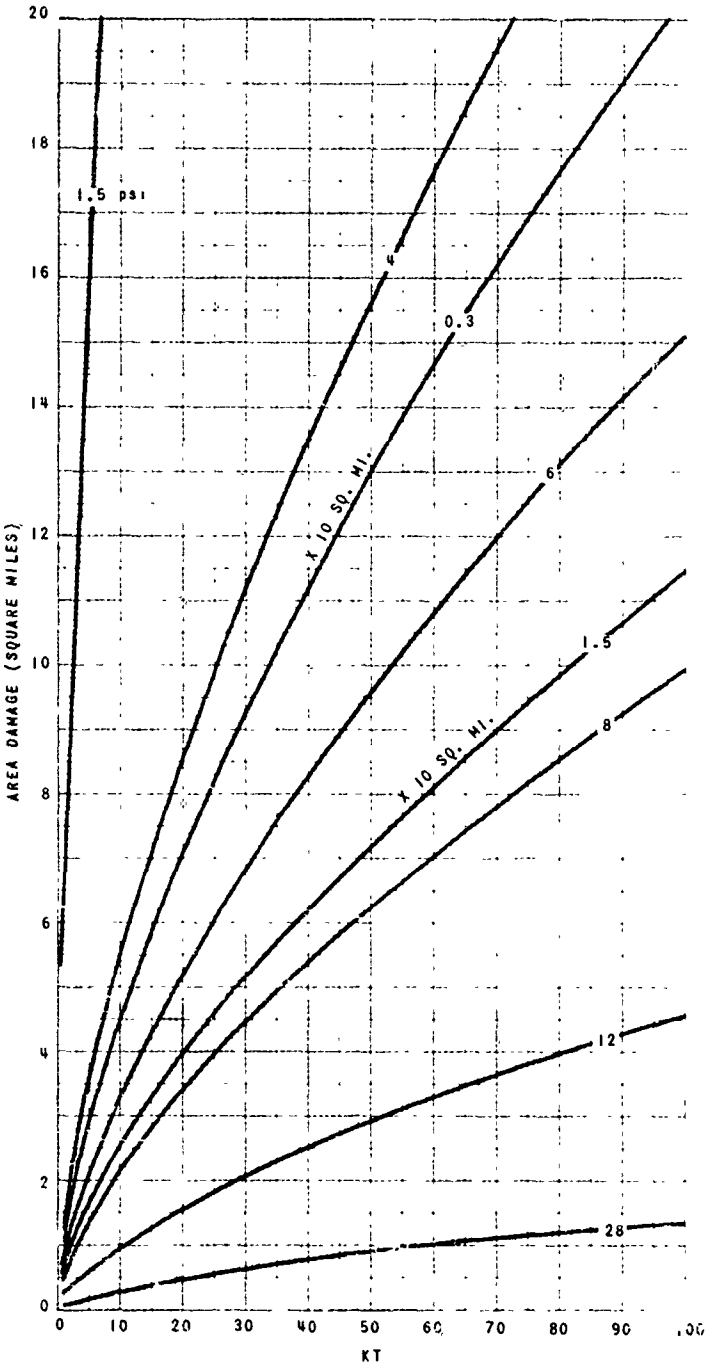

Figure 12.—Damage Areas within which the Overpressure is a Given Amount or Higher for Various KT Energy Atomic Weapons Exploded at Heights Optimized as Shown in Figure 10

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TABLE VIII
HEIGHTS OF BURST OF A 1 KT ATOMIC BOMB REQUIRED TO MAXIMIZE THE AREA SUBJECTED TO SPECIFIC OVERPRESSURES

OVERPRESSURE (POUNDS PER SQUARE INCH)	HEIGHT OF BURST (STATUTE MILES)	RADIUS OF OVERPRESSURE (STATUTE MILES FROM GROUND ZERO)
28.0	0. 126	0 142
12.0	0 175	0 261
8 0	0. 212	0. 383
6.0	0. 241	0. 473
4.0	0. 284	0. 606
1.5	0 322	1 30
0 3	0 340	5. 50

The last two lines of Table VIII were obtained by extrapolation

OVER-ALL EFFECTS

As stated in Table VIII, the blast resulting from the air burst of an atomic weapon represents the most important aspect of the atomic burst as far as destruction of property is concerned. The relatively long duration of the blast wave compared with a few milliseconds for a conventional weapon indicates that, whereas in the latter case structures receive practically the full impulse of the blast, before they have time to deflect, in the case of atomic weapons the peak pressure is constant over a relatively long period of time and, therefore, considerable deflection of the structures will take place. According to the scaling law used previously, the distance at which a given overpressure is achieved varies roughly as the cube root of the KT energy release. The area over which the shock pressure exceeds a certain value is thus approximately proportional to the two-thirds power of the KT energy and will correspond to the area of destruction because the length of duration of the shock wave is relatively long. In other words, if the energy release is doubled, the blast-damaged area is increased by the two-thirds power of 2 or by a factor of less than 1 6. The Japanese experience in which a 20 KT weapon was exploded at a height of 600 yards indicated that virtually complete destruction will occur out to a radius of approximately one-half mile from ground zero, corresponding to an area of destruction of about three-quarters of a square mile, and that severe damage will occur out to a radial distance slightly greater than one mile from ground zero corresponding to an area of four square miles. For weapons of other energies these distances and areas of destruction will vary as described previously when the heights of burst are scaled to maximize the blast effect. The accompanying curves fully describe the variations in damage effect for different energies and scaled heights of burst.

Against structures and personnel in areas containing structures the greatest damage to property will come from the explosion of an atomic weapon exploded at a height optimizing the blast effect since the secondary effects of the blast in destroying buildings, in scattering debris, and in causing fires from stoves, lamps, et cetera, together with the effects of the thermal and gamma radiation will produce the greatest combined damage and personnel casualties. Against personnel or troops in the open where there are no or very few structures, it has been seen that little difference results in the ground radii of gamma and thermal radiation effects from weapons up to 100 KT by again scaling the heights of burst according to the cube root of the KT energy. For this range of energies it can be concluded that the scaled heights obtained by maximizing blast effects will produce optimum results under all conditions.

Estimates were made of the ranges for 100 percent, 50 percent, and zero percent deaths and incapacitating casualties for various situations, and curves were drawn through these three points with what appeared to be a probable variation in slope. Some error may be present, therefore, in using single points. Figure 13 summarizes the approximate lethal and incapacitating effects on personnel in the open and wearing ordinary uniforms from gamma and thermal radiation for burst up to 100 KT for each of three atmospheric conditions.

Figure 14 gives estimates of deaths and incapacitations among troops in the open exposed to a 20 KT atomic weapon exploded in the air at a height of 600 yards for situations when either the ordinary uniform is worn or a special uniform previously described to withstand thermal radiation. Against men in the

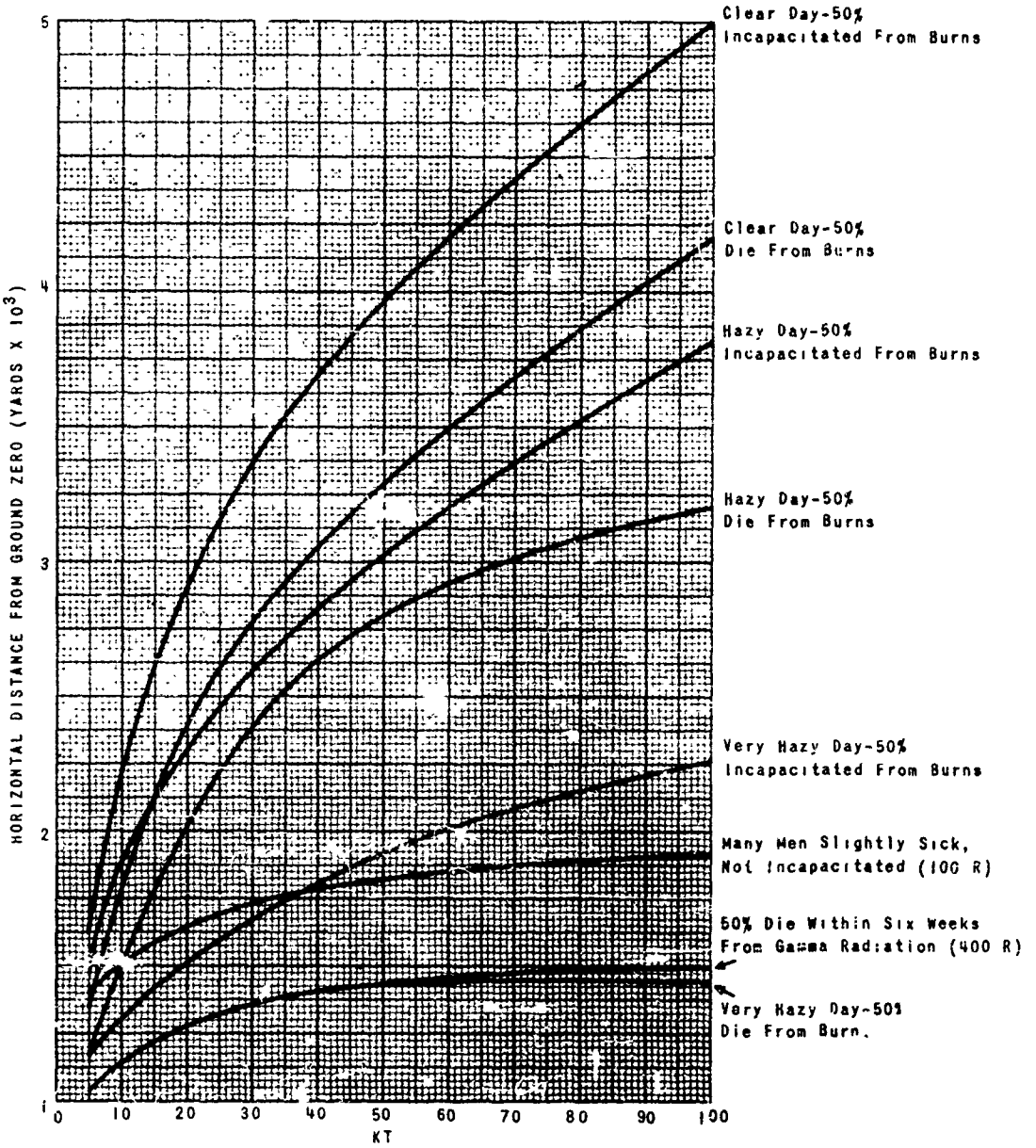

Figure 13.—Horizontal Distance from Ground Zero in Yards within which Lethal and Incapacitating Doses of Thermal and Gamma Radiation will be Received from Atomic Weapons of Various KT Energies Burst at Heights Given by the Cube Root of the KT Energy, Using 600 Yards Height for a 20 KT Weapon

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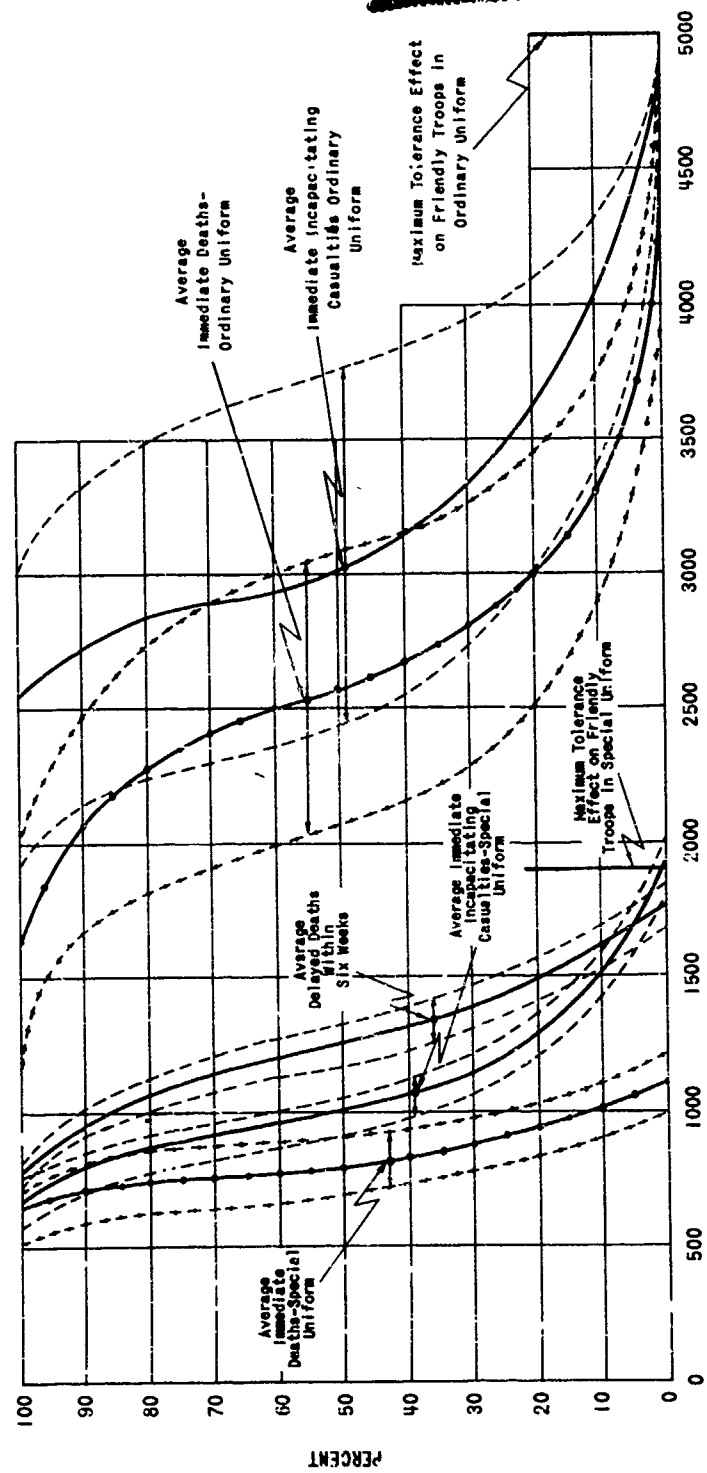

Figure 14.—Casualties Among Troops in the Open Exposed to a 20 KT Atomic Weapon Exploded in the Air at a Height of 600 Yards, on a Clear Day

(Note: In ordinary uniforms predominant cause of casualties is thermal radiation; in special uniforms it is gamma radiation; delayed deaths are principally those from gamma radiation.)

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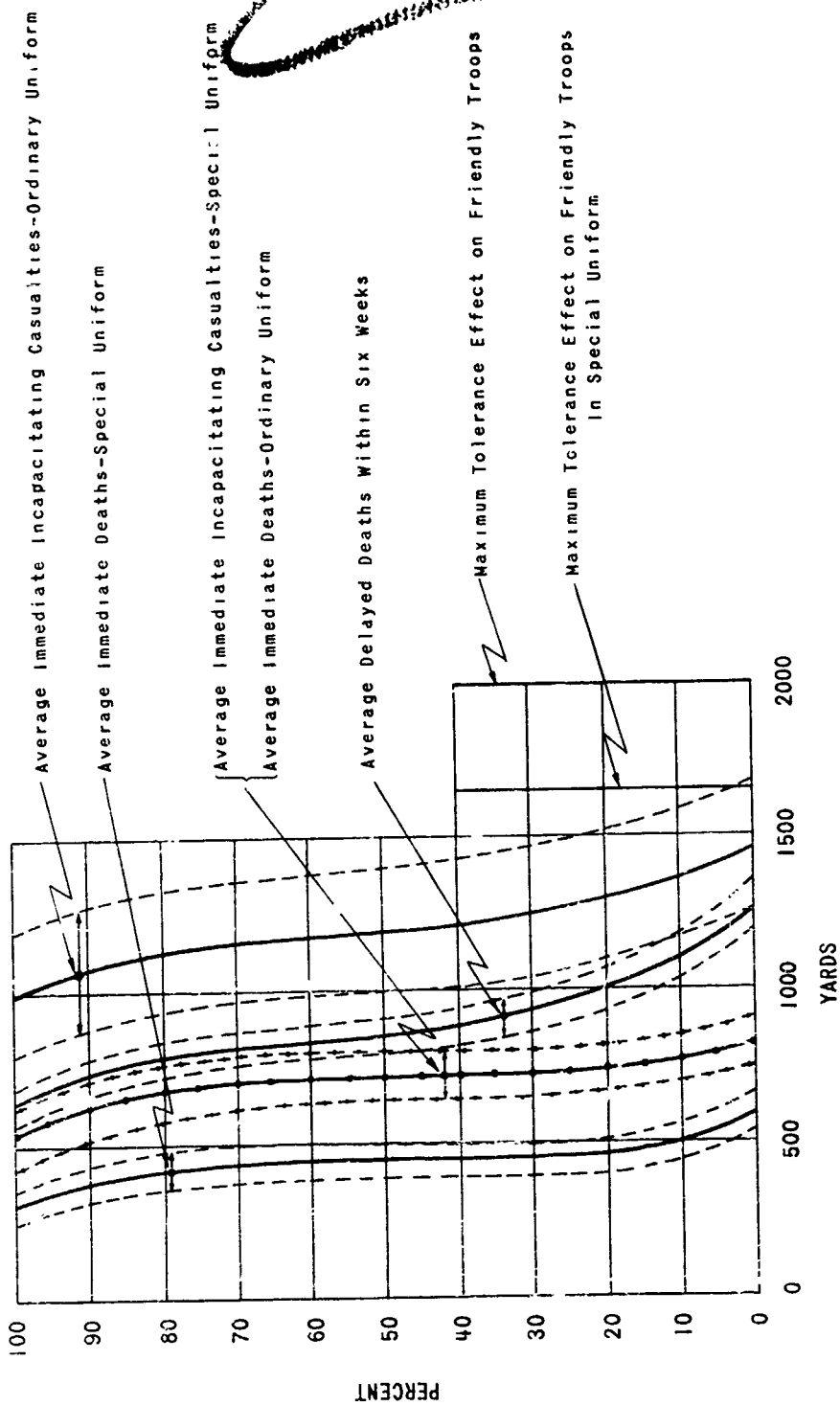

Figure 15. Casualties among Troops in Fox Holes Exposed to a 20 KT Atomic Weapon Exploded in the Air at a Height of 600 Yards, on a Clear Day

(Note: In ordinary uniforms predominant cause of casualties is thermal radiation; in special uniforms it is gamma radiation; delayed deaths are principally those from gamma radiation.)

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open in ordinary uniforms the effects from gamma radiation and, therefore, the predominant cause of casualties among such men will be thermal radiation. Where special uniforms are worn, thermal radiation damage is greatly reduced and the gamma radiation will predominate as the cause of casualties. The estimates of delayed deaths refer principally to those caused by gamma radiation. In addition to the average estimated casualties, data showing approximate upper and lower limits are shown. Attention is drawn to the overlapping regions in this data. Similar casualty information for any energy burst may be derived.

Figure 15 gives estimates of deaths and incapacitations among troops in fox holes exposed to a 20 KT atomic weapon exploded in the air at a height of 600 yards for situations when either the ordinary uniform or a special uniform designed to withstand thermal radiation is worn. This fox hole is considered to be the smallest practical one the man can dig and crouch into. In the present analysis we have used a fox hole 20 inches wide by 30 inches long and 54 inches deep. The criteria used in determining casualty data and ranges included:

1. In the first one-half second before the man crouches into the hole, he will receive approximately one-half the gamma radiation intensity and one-tenth the thermal radiation.

2. The man who cannot fight after one-half hour is considered a casualty to the tactical situation.

3. The man in the crouched position in the hole presents the surface of an ellipsoid to the radiation coming from the fireball.

4. The fox hole was estimated to provide a factor of four in protective ability over the corresponding situations in the open.

As in the case of troops in the open, thermal radiation is the predominant cause of casualties among troops in fox holes in ordinary uniforms, and gamma radiation for those in special uniforms. Gamma radiation alone is considered to cause delayed deaths. Upper and lower limits are again indicated.

The last two figures include also estimates of the maximum tolerance effect on friendly troops in the open and in fox holes when wearing ordinary or special uniforms.

Figure 16 gives estimates of deaths and incapacitations among troops in the open and in fox holes located in a medium dense wood, corresponding to the Second Growth Yellow Pine Forests of North Carolina, when exposed to a 20 KT atomic weapon exploded in the air on a clear day at a height of 600 yards. It is assumed that the men are in ordinary uniform. The estimates of casualties are based on the blast effect on the forest, thermal radiation including fires, and gamma radiation. These curves represent average values. Because of lack of specific information and to account for variations in actual situations, these curves are subject to deviations of at least ±500 yards in range.

The approximate nature of all the preceding estimates is to be noted and some caution used in their application.

CONCLUSIONS

1. The most effective use of an air burst atomic weapon of 20 to 100 KT energy against personnel is to detonate it at an altitude optimizing the blast area.

2. At the preceding altitudes the radii of the areas of corresponding damage from blast overpressures and thermal radiation are increased by a factor around 1.7 and the areas by a factor of 3 as the energy of the burst is increased from 20 to 100 KT.

3. As the energy of the burst increases, the thermal radiation, because of atmospheric attenuation as well as the inverse square law, increases only in a manner similar to the assumed increase for blast areas, i.e., approximately as the cube root of the energy for the radius.

4. For weapons up to 100 KT energy, atmospheric attenuation on a very hazy day can decrease the ground radius of the injurious thermal radiation intensities by a factor of about 2 from the radius for that intensity on a clear day.

5. For energies up to 100 KT and detonations at altitudes optimized for blast, the radius for 50 percent lethal thermal radiation intensity for personnel in the open exceeds, even under the most adverse atmospheric conditions considered, the radius for 50 percent

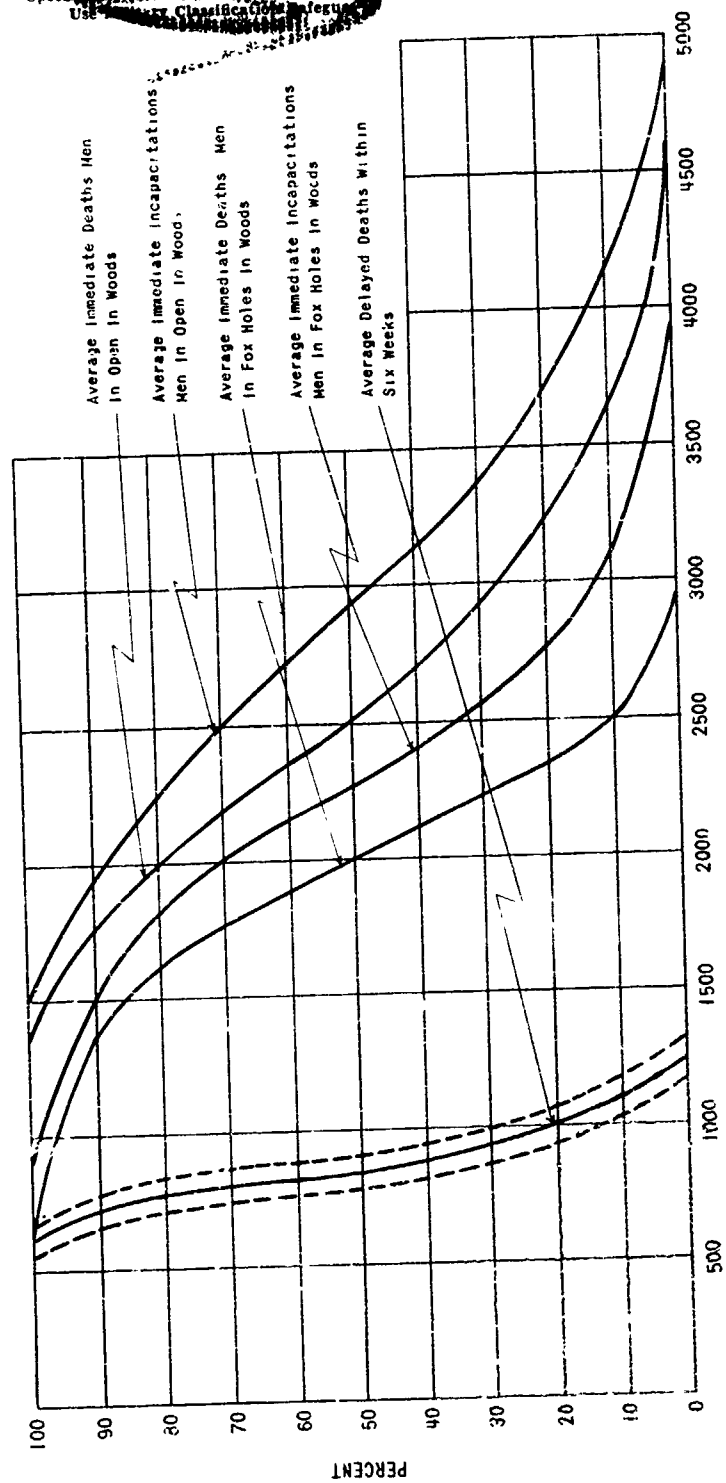

Figure 16.—Casualties Among Troops in a Forest Exposed to a 20 KT Atomic Weapon Exploded in Air at a Height of 600 Yards on a Clear Day (Note: These curves are estimated for medium dense woods corresponding to the Second Growth Yellow Pine Forests of North Carolina. It is assumed that men are in ordinary uniform. Casualties are based on blast effect on the forest, thermal radiation including fires and gamma radiation. Curves represent average values. Because of lack of specific information and to account for variations in actual situations, these curves are subject to deviations of at least ±500 yards in range.)

[redacted]

lethal (delayed) gamma radiation intensity from bursts optimizing the nuclear effect.

6. For all energies, the areas of nuclear radiation contamination will be a maximum when the altitude of bursts is held to a minimum. For this condition the radius for 50 percent lethal (delayed) intensity increases from 20 to 100 KT.

7. For all energies between 5 and 100 KT, the radius for a given intensity of thermal radiation, determined by optimizing the height of burst for blast, differs less than 10 percent from the radius for a constant 600-yard height of burst. The radius of any thermal radiation intensity area increases approximately as the cube root of the energy.

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ENCLOSURE A

DISTANCES FROM GROUND ZERO TO RECEIVE A LETHAL DOSE (400 R) AND A SICKNESS DOSE (100 R) OF GAMMA RADIATION FROM ATOMIC WEAPONS OF VARIOUS KT ENERGIES EXPLODED AT ASSUMED OPTIMUM HEIGHTS SCALED ACCORDING TO THE CUBE ROOT OF THE KT ENERGY USING 600 YARDS FOR 20 KT

From *Sandstone Report, Volume III*, Figure 1 shows the curve of the total gamma ray intensity times the slant distance squared as a function of the slant distance, obtained from data from the Bikini Able burst. Since the attenuation of gamma ray intensity is exponential, this curve is a straight line on semi-log plot. In general, the equation will be of the type

$$(r^2R)=ae^{-mr}$$

and the equation of the straight line will be given by

$$ln\ (r^2R)=ln\ a-mr$$

When $r=0$, $r^2R=3.8\times10^{10}=a$

and when $r=2{,}175$, $r^2R=10^8$

Therefore $m=2.74\times10^{-3}$

The final equation of the curve thus becomes

$$ln\ (r^2R)=ln\ (3.8\times10^{10})-2.74\times10^{-3}r$$

CONDITION A: TO RECEIVE A LETHAL DOSE (400 R)

When $R=400$

$$ln\ r^2=ln\ (3.8\times10^{10})-ln\ 400-2.74\times10^{-3}r$$

When the energy of the weapon is varied, the exposure dose of 400 R will be experienced at slant distance r given by using a scaling factor $20/T$ since the above equation holds for a 20 KT burst at a height of 600 yards.

Therefore,

$$ln\ r^2=ln\ (3.8\times10^{10})-ln\ (400\times20/T)-2.74\times10^{-3}r$$

or, finally

$$ln\ r^2+2.74\times10^{-3}r=ln\ (4.75\times10^6T)$$

CONDITION B: TO RECEIVE A SICKNESS DOSE

This condition simply substitutes $R=100$ in the original equations and, scaled in the same way, gives the final equation

$$ln\ r^2+2.74\times10^{-3}r=ln\ (1.90\times10^7T)$$

The values obtained for slant distances and horizontal distances from ground zero are shown in Table 1 and Figure 2 for various KT energies of the bomb, assumed burst at a height given by $600\times(T/20)^{1/3}$ yards.

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ENCLOSURE B

DISTANCE FROM GROUND ZERO TO RECEIVE A LETHAL DOSE (6.5 cal/cm²) AND AN INCAPACITATING DOSE (4.0 cal/cm²) OF THERMAL RADIATION FROM ATOMIC WEAPONS OF VARIOUS KT ENERGIES EXPLODED AT ASSUMED OPTIMUM HEIGHTS SCALED ACCORDING TO THE CUBE ROOT OF THE KT ENERGY USING 600 YARDS FOR 20 KT

ETHAL DOSE
cal/cm²) OF
VARIOUS KT
HTS SCALED
Y USING 600

$$I\ (\text{cal/cm}^2) = I_0 \frac{e^{-\alpha r}}{r^2}$$

where I_0 is the initial thermal radiation intensity (one-third of the total energy from the explosion, r is the slant distance from the bomb to the ground, and α is the coefficient of absorption of the thermal radiation by the air in terms of visibility; and I is the intensity received at any point r.

$$I = \frac{8.4\times10^{20}\ (\text{ergs})\times\frac{T}{20}\times e^{-\alpha r}}{3\times4\pi\times(4.1855\times10^7)\ (\text{ergs/cal})\times r^2\ (\text{cm}^2)}$$

(T=KT energy)

$$I = \frac{6.4\times10^7\times\frac{T}{20}\times e^{-\alpha r}}{r^2}$$

(r in yards)

and

$$r^2 = \frac{6.4\times10^7\times\frac{T}{20}\times e^{-\alpha r}}{I}$$

CONDITION A: CLEAR DAY, VISIBILITY 10–12–20 MILES

$$\alpha = 0.2/Km = 2.2\times10^{-4}/\text{Yd.}$$

$$2\ ln\ r = ln\ (6.4\times10^7) - \alpha r - ln\ I + ln\ \frac{T}{20}$$

$$2\ ln\ r + 2.2\times10^{-4}r - 17.9744 + ln\ I - ln\ \frac{T}{20} = 0$$

CONDITION B: HAZY DAY, VISIBILITY 4–6–8 Miles

ZY DAY,
Miles

$$\alpha = 0.4Km = 4.4\times10^{-4}/\text{Yd.}$$

$\alpha = 4.4\times10^{-4}/\text{Yd.}$

$$2\ ln\ r = ln\ (6.4\times10^7) - \alpha r - ln\ I + ln\ \frac{T}{20}$$

$10^7) - \alpha r - ln\ I + ln\ \frac{T}{20}$

$$2\ ln\ r + 4.4\times10^{-4}r - 17.9744 + ln\ I - ln\ \frac{T}{20} = 0$$

$= 17.9744 + ln\ I - ln\ \frac{T}{20} = 0$

CONDITION C: VERY HAZY DAY, VISIBILITY 1–2.5–4 MILES

RY HAZY DAY,
4 MILES

$$\alpha = 1.0/Km = 1.1\times10^{-3}/\text{Yd.}$$

$\alpha = 1.1\times10^{-3}/\text{Yd.}$

$$2\ ln\ r = (6.4\times10^7) = \alpha r - ln\ I + ln\ \frac{T}{20}$$

$= \alpha r - ln\ I + ln\ \frac{T}{20}$

$$2\ ln\ r + 1.1\times10^{-3}r - 17.9744 + ln\ I - ln\ \frac{T}{20} = 0$$

$= 17.9744 + ln\ I - ln\ \frac{T}{20} = 0$

With the heights of burst scaled acc of burst scaled according to the cube root of the KT energy, usin the KT energy, using 600 yards for 20 KT, the values of the horiz e values of the horizontal distances from ground zero as a functi und zero as a function of the KT energy giving various thermal ing variou thermal radiation intensities are shown in Figures 3, shown in Figures 3, 4, 5, and 6. The values of ground distances of ground distances within which a lethal dose (6.5 cal/cm²) of th (6.5 cal/cm²) of thermal radiation intensity will be received are will be received are shown in Table 4.

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ANNEX 2

WORLD WAR II TACTICAL SITUATIONS ANALYZED WITH RESPECT TO ATOMIC WEAPONS

Prepared by

W. L. WHITSON
K. D. BARTIMO
D. K. CLARK
A. D. COOX
W. B. COTTRELL
G. N. DONOVAN
E. S. GILFILLAN, JR.
K. C. HAFSTAD
W. B. HEINZ
N. M. SMITH, JR
S. H. TURKEL
W. H. WELLS

20 January 1950

R[redacted]
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PROJECT *MAID*

20 January 1950

Annex 2

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WORLD WAR II TACTICAL SITUATIONS ANALYZED WITH RESPECT TO ATOMIC WEAPONS

SUMMARY

PROBLEM

The problems are to determine the effect of using atomic weapons on certain World War II tactical situations, and to set up techniques of analysis which may be used in the evaluation of atomic weapons employed in ground operations.

FACTS

Existing reports have emphasized the value of studying the use of atomic weapons in a number of WWII situations such as Cassino, St. Lo, Bastogne, Anzio, Falaise, Leningrad, Moscow, Stalingrad, Kharkov, Normandy landing, Iwo Jima, Crete, Okinawa, Cherbourg, El Alamein, Volkhov, Orsha, Central Poland January 1945 Berlin assault, Makin, and Tarawa.

In recommending study of these situations, the suggestion has been that the concentrations of personnel and equipment were, in these situations, most likely to be enough to warrant the use of atomic weapons.

Records of several of these situations have been obtained, although in most cases it has been difficult to obtain information in sufficient detail. In some instances no information was available about some phases. The situations analyzed in the enclosures are:

Enclosure A: Anzio
B: Cassino
C: El Alamein
D: St. Lo
E: Volkhov
F: US First Army

In addition to these actual situations the Standard Operating Procedures for Offensive Action of both the US and USSR are examined in Enclosure G.

Information on atomic weapons effects is not yet sufficiently complete to allow a thorough analysis. This is particularly true of the effect on equipment. Even when the basic information is more nearly complete, there will be the further task of applying the basic facts to all the various kinds of equipment.

The natural and artificial shielding afforded by terrain, buildings, equipment, et cetera, complicates analysis to the extent that simplifying assumptions are requisite.

The work which is reported here is a first approximation only. With few exceptions the analysis has been confined to determining personnel casualties.

DISCUSSION

A consideration of the effectiveness of atomic weapons when employed in ground operations must, of course, include the possibility that the next war may be fought differently, at least in some respects, than any previous war has been fought. A contributing factor may well be the effect of atomic weapons themselves. A first approximation to the problem could be to first imagine that an atomic weapon was used in a situation which in all other respects remained the same. As a result of this first analysis, changes in the tactics and in the deployment of men and equipment could be assumed including, for example, special protective clothing or more dispersal.

This has been the procedure in these studies. In most instances only the first approximation has been made: that an atomic bomb was dropped on the situation as it actually existed. It is not pretended that any of these studies are complete and final. They do, however, seem to afford a profitable framework for some preliminary conclusions.

There has been a tendency in the past to assume that *on the average* the targets set up by ground operations were not profitable targets for an atomic weapon. This is believed to be a result of the feeling that there were *very few* atomic bombs and that they *cost very much*. Both concepts are relative. It was noticed early in this work that *one* atomic bomb could do a great deal of damage on *one* infantry division. As a result, there was a tendency not to find the most lucrative targets from WWII but to see what damage resulted in various kinds of operations. The Volkhov analysis here is not of the Soviet situation which is presumed to involve very heavy concentrations but of the German situation. The US First Army was studied, not for heavy concentration, but primarily to see what resulted in more nearly average situations. Finally, it was decided to set up a theoretical situation corresponding as well as could be done to the standard operating procedures in both the US and USSR armies. Again it is emphasized that for the most part this is an introduction to such analysis. It considers mainly the effects on personnel and very little the effects on equipment. Even the effects on personnel are idealized regarding, for example, terrain effects, to the extent that the estimates are in most cases maximum casualties more nearly than expected casualties.

CONCLUSIONS

A limited number of atomic bombs could have been used very effectively in many WWII situations.

During the phase of attack and preparation for attack, an infantry division is much more vulnerable to an atomic attack than when on the defensive.

One air burst atomic bomb dropped with even fair accuracy will cause severe casualties to the personnel of *one* division of infantry.

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ENCLOSURE A

ANZIO BEACHHEAD

by

Edward S. Gilfillan, Jr. and Grace Donovan

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ANZIO BEACHHEAD

OBJECT

The object of this study is to determine whether or not there was a point at which either the Allied VI Corps or the opposing German XIV Army could have made effective tactical use of an atomic bomb on the beachhead at Anzio.

CONCLUSIONS

The Allies could have achieved a breakthrough by using an atomic bomb on 31 January 1944 in the region of Station Campoleone around which the enemy was massing his greatest troop concentrations in preparation for a 1 February German offensive. At that same time, if the Germans could have used an atomic bomb against the Allied forces concentrated in a narrow salient south of Campoleone, they could have split the Allied forces on the beachhead in two, infiltrated among them through Padiglione woods, and probably driven the VI Corps off the beachhead.

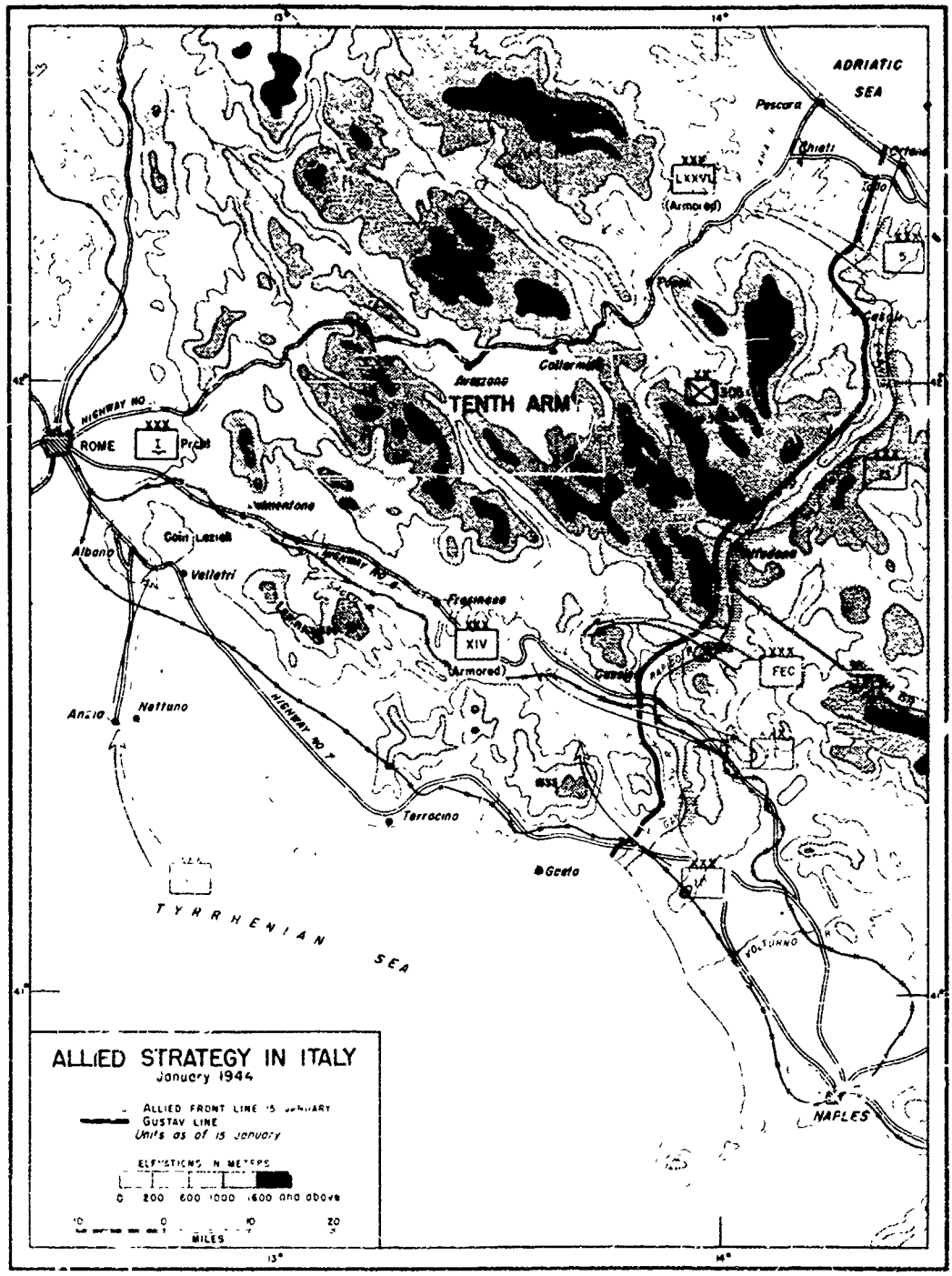
Note. It should be further kept in mind that uniforms specially designed to reduce the number of burns from the bomb flash are possible and very likely to be effective. The use of such uniforms has not been assumed here. Had this assumption been made, the computed casualties would have been much lower. Also, it has been calculated that fox holes offer very good protection from atomic bomb effects at distances from ground zero greater than 800 yards from ground zero. Finally, one should remember that the hypothetical weapons effects assumed here are grossly approximate and that, within wide limits, no one really knows what the effect of atomic bombs on troops would be. This study is merely an attempt to use the best available information to estimate the casualties to be expected—nothing more.

HISTORICAL[a]

The winter months of 1943-1944 found the Allied forces in Italy slowly battering their way through the rugged mountain barriers blocking the roads to Rome. The main defensive barrier guarding the approach to Rome was the Gustav Line extending across the Italian peninsula from Minturno to Ortona. Buttressed by snow-capped peaks flanking the Liri Valley and protected by the rain-swollen Garigliano and Rapido Rivers, the Gustav Line was an even more formidable barrier than the Winter Line. Unless some strategy could be devised to turn the defenses of the Gustav Line, the Fifth Army faced another long and arduous mountain campaign. The Allied staffs decided on a plan for landing behind the enemy lines with the purpose of turning the German flank, gaining a passage to the routes to Rome and threatening the enemy lines of communication and supply. Two divisions, plus airborne troops and some armor, were to make the initial assault between 20 and 31 January 1944.

Main Fifth Army reinforced by two fresh divisions from the 8th Army was to strike at the German 10th Army across the Garigliano and Rapido Rivers, breach the Gustav Line and drive up the Liri Valley. While the enemy was fully occupied in defending the Gustav Line, the surprise landing would be made in the rear at Anzio and Nettuno, about 30 miles south of Rome. The VI Corps was to land at 0200 on D-Day, 22 January, and secure the beaches extending north and south from Anzio for a distance of about six miles in each direction. After securing the initial objectives it was to be prepared to advance across the flat hinterland in the direction of the Colli Laziali hill mass which rises to a height of 3,000 feet and controls all routes from the south toward Rome. The capture of Colli Laziali would block vital enemy supply routes and threaten to cut off the German troops holding the Gustav Line. Thus weakened, the Germans could be forced to withdraw up the Liri Valley from their Gustav Line positions. Main Fifth Army was to follow up the anticipated enemy withdrawal as quickly as possible, link up with the beachhead force and drive on Rome (Map 1).

[a] This account is from: *Anzio Beachhead*, Department of the Army, Historical Division, 10 October 1947 and VI Corps Historical Record, Anzio Beachhead, January 1944.



Map 1.—Allied Strategy in Italy, January 1944.

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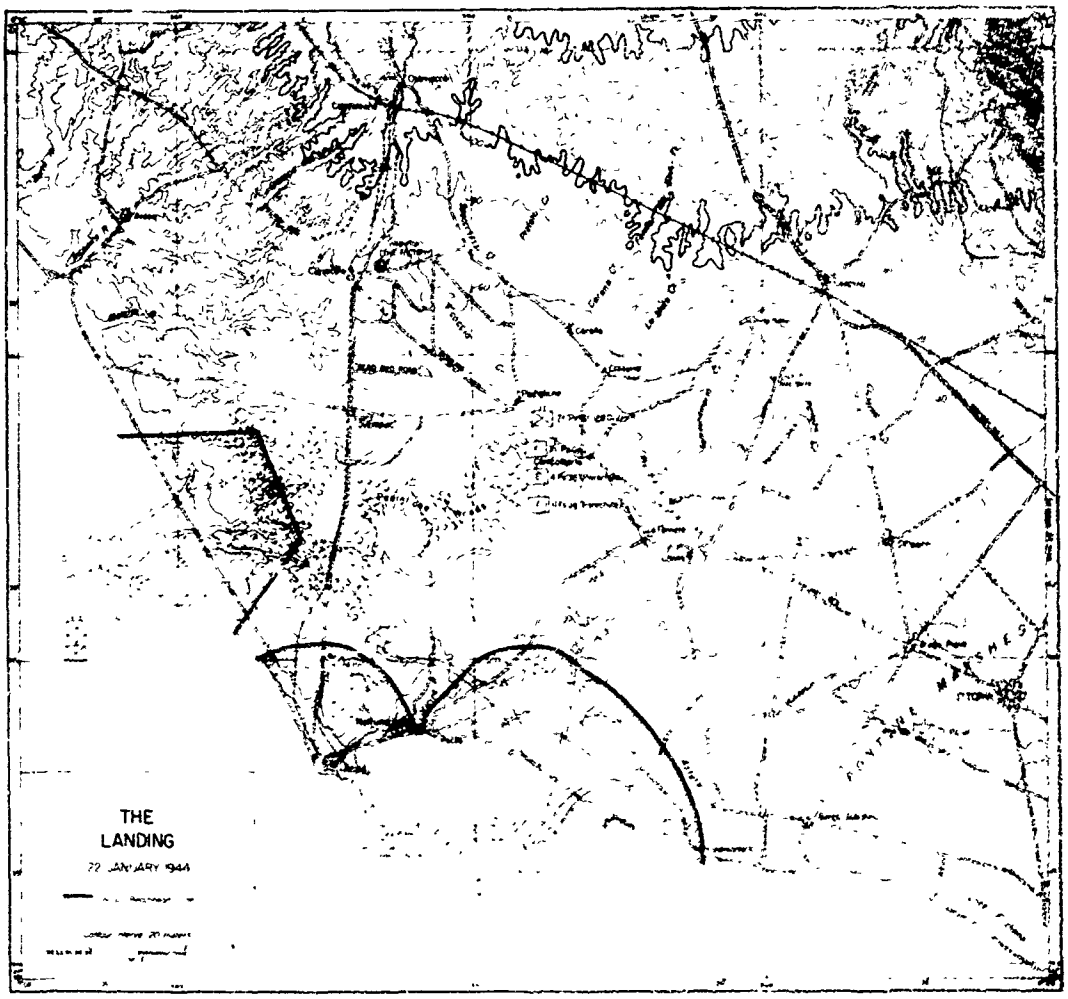
THE LANDING

At 0200, 22 January 1944, the landings at Anzio and Nettuno commenced and by midnight of D-Day some 36,000 men, 3,200 vehicles, and large quantities of supplies were ashore. This represented approximately 90 percent of the equipment and personnel of the assault convoy and included on the right or southern flank the 3rd US Inf Div (consisting of the 7th, 15th, and 30th Inf) in the northern zone, the 1st British Infantry Division (consisting of 3 battalions and the 24 Guards Brigade and 46 Royal Tanks), and the 6615th Ranger Force (consisting of the 1st, 3rd, and 4th Ranger Bn and the 509th Parachute Bn) who destroyed existing defense batteries and cleared the beach area between Anzio and Nettuno (Map 2 and Table IX).

Although the landing itself was practically unopposed, before the end of D-Day the Germans were estimated to have 20,000 troops in areas from which they could drive rapidly toward the beachhead. They doubled the figure by D+2 and continued to increase it to 71,500 by 30 January, at which time the VI Corps had 61,332 troops, having been augmented by the arrival on 25 January of the



Map 2.—The Landing, 22 January 1944

1st Combat Team of the 45th Div, the 179th Inf, and the 1st Armored Div on 28 January.

TERRAIN

The area over which the VI Corps had made its landing is a stretch of the narrow Roman coastal plain extending north from Terracina across the Tiber River. Southeast of Anzio the plain is covered by the Pontine Marshes; northwest toward the Tiber it is rolling farm country, often wooded. Twenty miles inland from Anzio the plain is bounded by the volcanic heights of Colli Laziali, a 3,100-ft hill mass guarding the southern approaches to Rome. East of Colli Laziali the mountains fall into the valley by Velletrie, leading inland toward Highway 6 at Valmontone.

The coastal plain around Anzio is divided into three major sections. First is a 5-mile belt of low scrub timber interspersed with bare, open fields which encircles the port of Anzio. This waste land proved of marked value to our beachhead because it both screened the port and beach areas from enemy observers inland and afforded concealed dumps and bivouac areas for our troops. North of this wooded section the beachhead area is divided into two parts by the Albano road, the main highway leading inland from Anzio. West of the road the plain is cut by a series of stream gullies, the largest of which are the Moletta and Incastro running southwest from the slopes of the Colli Laziali toward the sea. These gullies are often 50 ft deep and proved difficult obstacles for armor.

TABLE IX
HEADQUARTERS VI CORPS
APO 306
Troop List
161200 January 44

Hq VI Corps
- Hq Co VI Corps

3rd Inf Div
- 601st TD Bn
- 441st AAA AW Bn
- 69th Armd FA Bn
- Btry B 36th FA
- 751st Tk Bn
- 84th Cml Bn
- 2d Plat 48th QM GR Co
- Det 163d Sig Photo Co (6 men)
- Det Btry B 15th FA Obsn Bn (42 men)

1st Inf Div (Brit)
- Det 163d Sig Photo Co (3 men)
- Det 51st Sig Bn (10 men)
- Det 229th Sig Ops Co (15 men)
- Det 57th Sig Bn (19 men)
- 377th MP Escort Guard Co (less 1st Plat)
- 239th GT Coy (DUKWS)
- 11th Field Cash Office
- 1 Sec 25th [illegible]
- Det J Service
- 46th Royal Tk Rgt (Brit)
- 24th Armed Fld. Regt RA (105mm SP) (Brit)
- 80th Med Regt RA (One Btry 4.5", One Btry 5.5") (Brit)
- 1 Flight 655th Air OP Sq (Brit)
- Det 7/9 AASC (Brit)
- 25th Field Surg Unit (Brit)
- 2 Secs 485th Army Fld. Serv ACC (Brit)
- Det 1st Reception Camp (Brit)
- 373d PW Camp (Brit)
- 3d Beach Gp (Brit)
- 9th Beach Sig Sec (Brit)

540 Engr C Regt
- Det 6th Cml Dep Co w/det 11th Cml Maint Co (17 Jan)
- 24th Cml Decon Co (17 Jan)
- 66th Ord Am Co
- Det 45th Ord Bn
- Cos A & B 52d Med Bn
- Det 2d Aux Surg Gp (3 teams)
- 1st Sec Adv Plat 12th Med Dep Co
- 1st & 2d Plats 33d Field Hosp
- Co A 504th MP Bn
- Det 85th QM Dep Co
- 1st Sec 2d Plat 47th QM GR Co
- 1st Plat 94th QM Rhd Co
- 249th QM Serv Bn (less Cos A & B)
- 1st Plat 9853d QM Gas Sup Co
- 690th AAA A/B MG Btry
- 692d AAA A/B MG Btry
- 1st Plat 377th MP Escort Guard Co
- Cos A & D 387th Engr Bn Sep
- Det 462d Engr Dep Co (12 men)
- 74th Sig Co (Spec) atchd;
  - Det 212th Sig Dep Co
  - Det 180th Sig Rep Co (12 men)
  - Det 817th Sig Port Serv Co
  - Det Brit Sig 1st Inf Div (Brit)

Medical
- 93d Evac Hosp
- 95th Evac Hosp
- Det 2d Aux Sur Gp (9 teams)
- 52d Med Bn (less Cos A & B)
- 33d Field Hosp (less 1st & 2d Plats) 12th FTU (Brit)
- 56th Evac Hosp

[redacted]

TABLE IX (*Continued*)

QM
- 53d QM Trk Bn (less Co A)
- 94th QM Rhd Co (less 1st Plat)
- 3853d QM GS Co (less 1st Plat)
- 52d QM Bn Mobile
- Hq & Hq Det 488th Port Bn (20 Jan)
  - 188th Port Bn (20 Jan)
  - 189th Port Bn (20 Jan)
  - 190th Port Bn (20 Jan)
  - 191st Port Bn (20 Jan)
- 6723d Trk Cp, Prov
- Co A 249th QM Bn (Serv)

6615th Ranger Force (Prov)
- 1st Ranger Bn
- 3d Ranger Bn
- 4th Ranger Bn
- 509th Prcht Inf Bn
- 83rd Cml Bn (less Cos C & D)
- Co H 36th Engr C Regt
- Det 163d Sig Photo Co (3 men)
- Det 57th Sig Bn (27 men)

504th Prcht Inf Regt
- 376th Prcht FA Bn
- Co C 307th A/B Engr Bn
- Det 163d Sig Photo Co (3 men)

68th CA Regt (AA) (less 3d Bn)
- 106th AAA AW Bn
- Det 102d AA Bln Btry (VLA)

FA
- 1st Bn 77th FA Regt
- 1st Bn 36th FA Regt (less Btry B)
  - Btry B 15th Obsn (less Det)

Tank Destroyer
- 894th TD Bn

MP
- Hq & Hq Det 504th MP Bn
- Co C 504th MP Bn
- 206th MP Co

Engrs
- Co B 405th Engr WS Bn
- 36th Engr C Regt (less Co H)
- 39th Engr C Regt
- 661st Engr Topo Co
- Cos A & C 387th Engr Bn (Sep)
- 1 Plat 462d Engr Depot Co (less Det) (on arrival)

57th Sig Bn
- Det C 71st Sig Co (Spec)
- Det B 128th Sig (RI) Co
- Det E 819th Sig Int Serv
- #1 Lp Ln Det (Cipher)
- Det 163d Sig Photo Co
- Det 180th Sig Rep Co

CWS
- Cos C & D 83d Cml Bn

Ordnance
- Hq & Hq Det 45th Ord Bn
  - 14th Ord MM Co
  - 45th Ord MM Co
  - Det 525th Ord Hv M Co (TK)
  - 3407th Ord MM Co (QJ)
  - 58th Ord Am Co
- 56th Ord Bomb Disp Sq

British Units (Corps Troops)
- 15th Stores Section
- 2 CCS
- 1548 Arty Pl RASC
- 15101 Arty Pl RASC
- 12 FTU

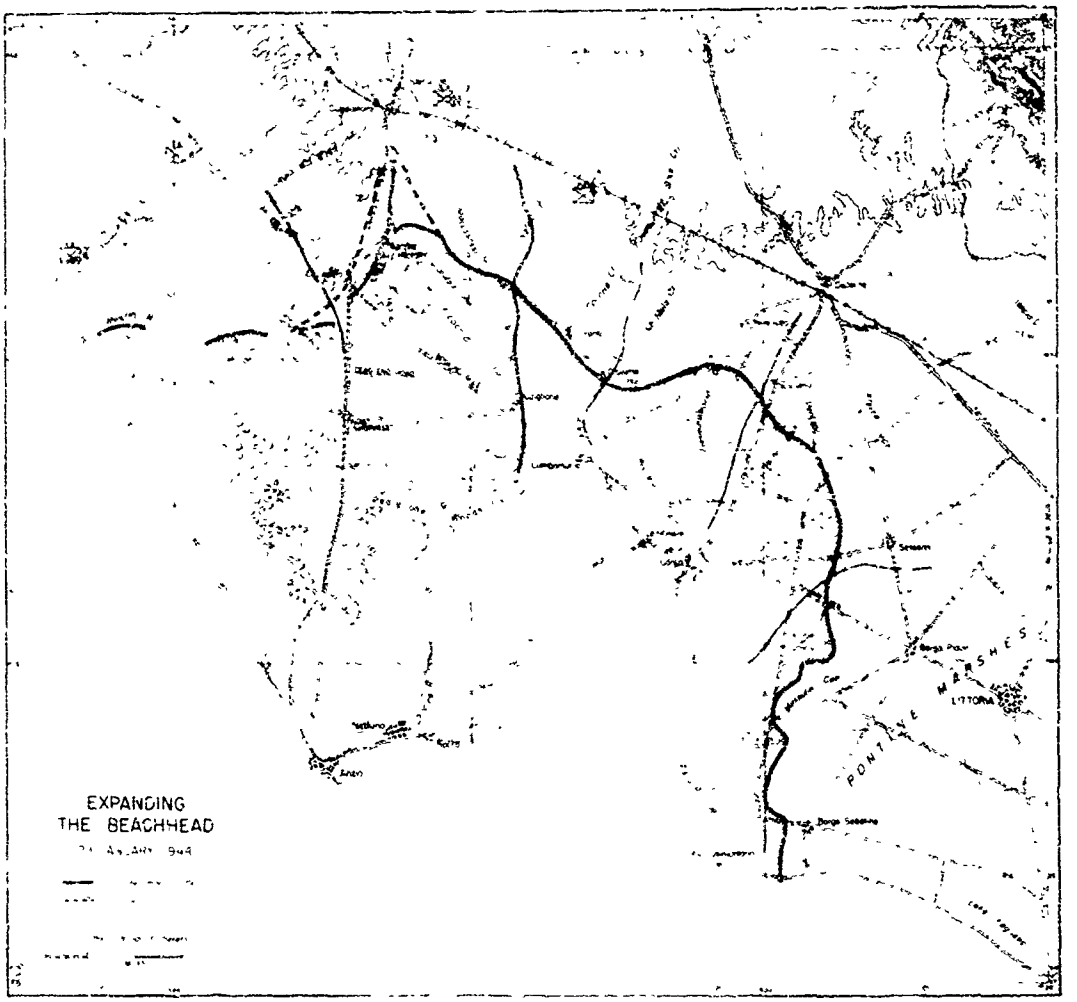
East of the Albano road gently rolling cultivated fields stretch east toward Cisterna. Along this region of open country, extending north from the first railroad overpass on the Albano road past Carroceto and Campoleone to Colli Laziali lies the best avenue of approach in or out of the beachhead, which was to be the scene of major German and Allied attacks. On the east these fields shade into the northern edge of the Pontine Marshes, a low, flat region of irrigated fields interlaced with an intricate network of drainage ditches. Their treeless, level expanse offers scant cover for any troops, and during the rainy season heavy equipment would bog down in the fields.

The entire area is spotted with new standardized two-story poderi, or farmhouses, standing at frequent intervals along the network of paved and gravel roads crisscrossing the farm lands. (See Supplement C.)

24–29 JANUARY

An area approximately 7 miles deep by 15 miles wide around Anzio was chosen for consolidation as the initial Allied beachhead. Its 26-mile perimeter was considered the maximum which could be held by General Lucas' limited forces, yet include the best natural features for defense. The Allies consolidated their position on the beachhead during 24–29 January. By 29 January, the VI Corps had expanded its beachhead by the advances of the 1st and 3rd Div but was still from 2 to 4 miles short of its two intermediate objectives of Cisterna and Campoleone (Map 3).

In view of the rapidly increasing enemy build-up, General Lucas decided to launch a drive toward Colli Laziali on 30 January before his forces might be too greatly outnumbered. Field Order #20 was issued. It em-



Map 3.—Expanding the Beachhead, 29 January 1944

bodied the plan for a Corps attack on 30 January to seize the high ground in the vicinity of Colli Laziali, block the highway leading southeast out of Rome, and prepare to continue the advance on Rome. The 3rd Div with the Rangers and paratroops was to attack on the morning of 30 January, capture Velletrie and consolidate the surrounding area, then seize Albano and Cenzano and the surrounding high ground and prepare to advance north. The 1st Armored Div, minus Combat Command B was to advance along the Anzio-Albano road, seize high ground west of Marino and continue northward to cut the roads leading east and southeast from Rome. The 45th Div, minus the 179th RCT was to prepare to attack to the north and east on Corps order[9] (Map 4).

The Germans originally planned to counterattack the Allied beachhead in force on 28 January. But, Allied bombings of roads and railroads and a desire to await the arrival of reinforcements from Germany led to a decision on 26 January to postpone the attack until 1 February. In preparation, the enemy

[9] The Mounting and Initial Phase of Operation "Shingle," VI Corps Historical Record, January 1944.

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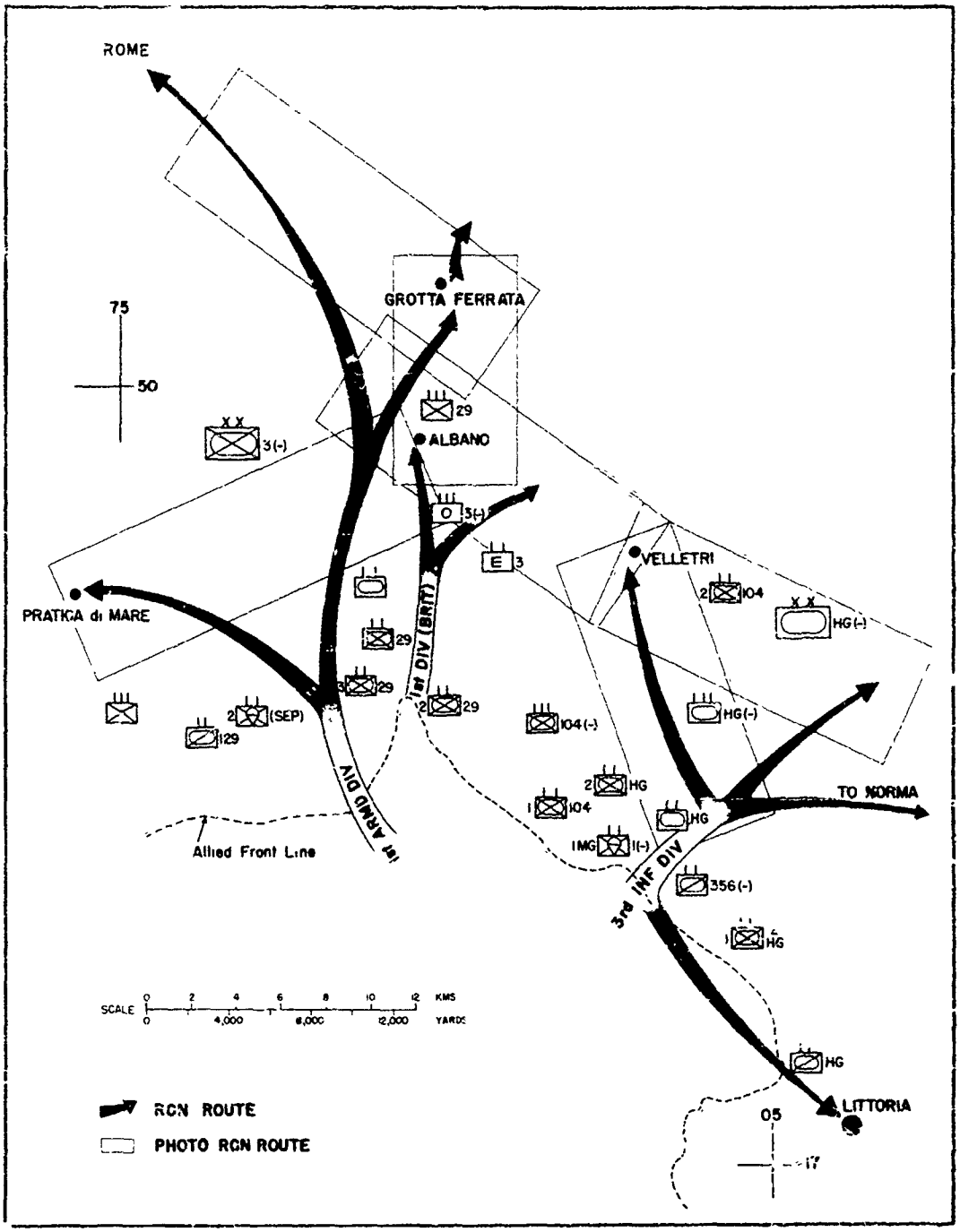

Map 4.—The Allied Offensive Plan, 28 January 1944

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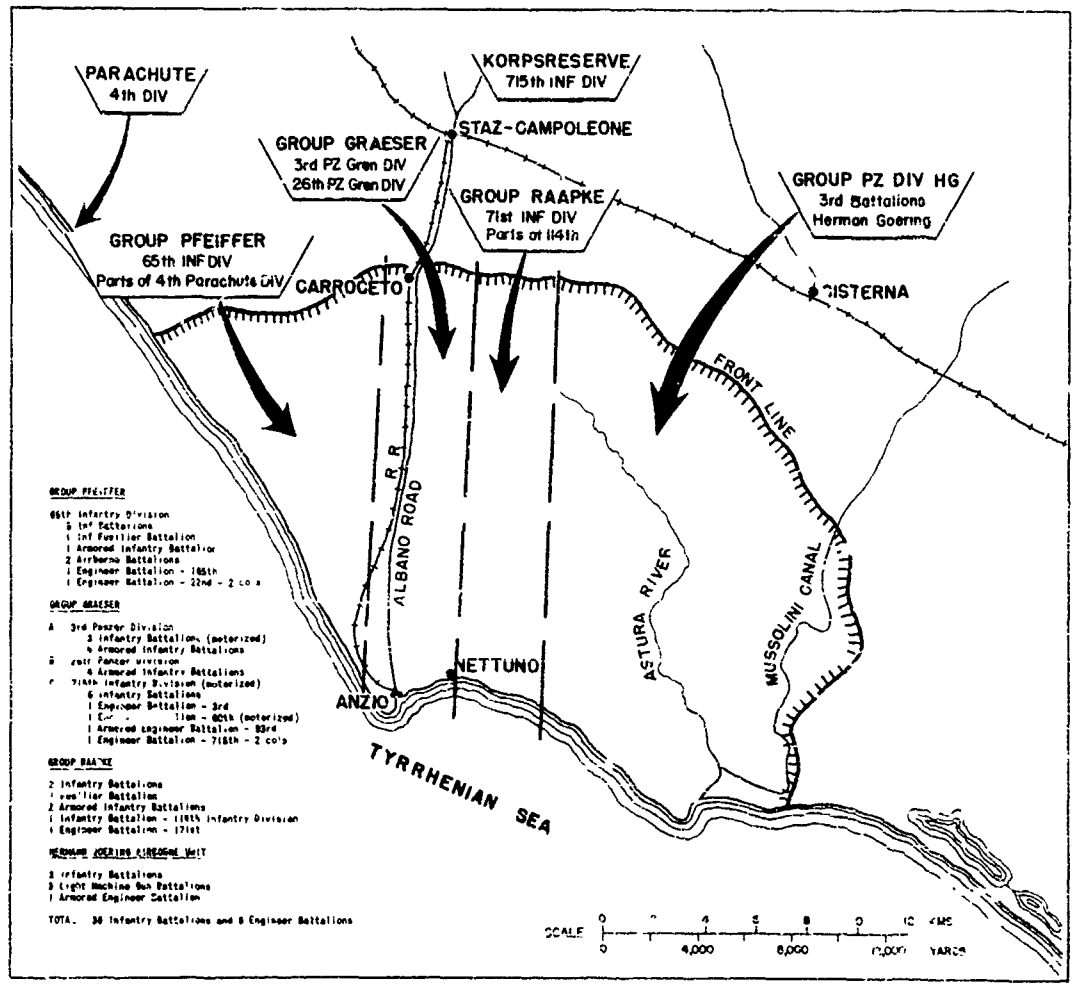
proceeded to arrange his infantry and artillery into 3 combat groups. The principal assault was to be launched southward along the Albano-Anzio road (with main concentrations on either side of the Factory) by Combat Group Graeser which would consist of 17 infantry battalions heavily supported by artillery. While the main effort was to be made in the center, the Germans planned to launch simultaneous attacks all along the front with their remaining 19 infantry battalions, on the morning of D-Day, 1 February (Map 5).

While the necessary regroupings were underway the Allied VI Corps launched its offensive on 30 January forcing the Germans to postpone their attack.

THE ALLIED OFFENSIVE OF 30 JANUARY

ATTACK ON CISTERNA, 30 JANUARY–1 FEBRUARY

On 30 January the 3rd Div launched its drive to cut Highway 7 at Cisterna (Map 6). The 1st and 3rd Ranger Battalions were to start one hour before the main attack and infiltrate under cover of darkness 4 miles across the fields to seize Cisterna by surprise. The 7th Inf was to operate on the left of the Ranger Force and the 15th Inf on the right.



Map 6—German Troops and Plan for 1 February 1944 Offensive

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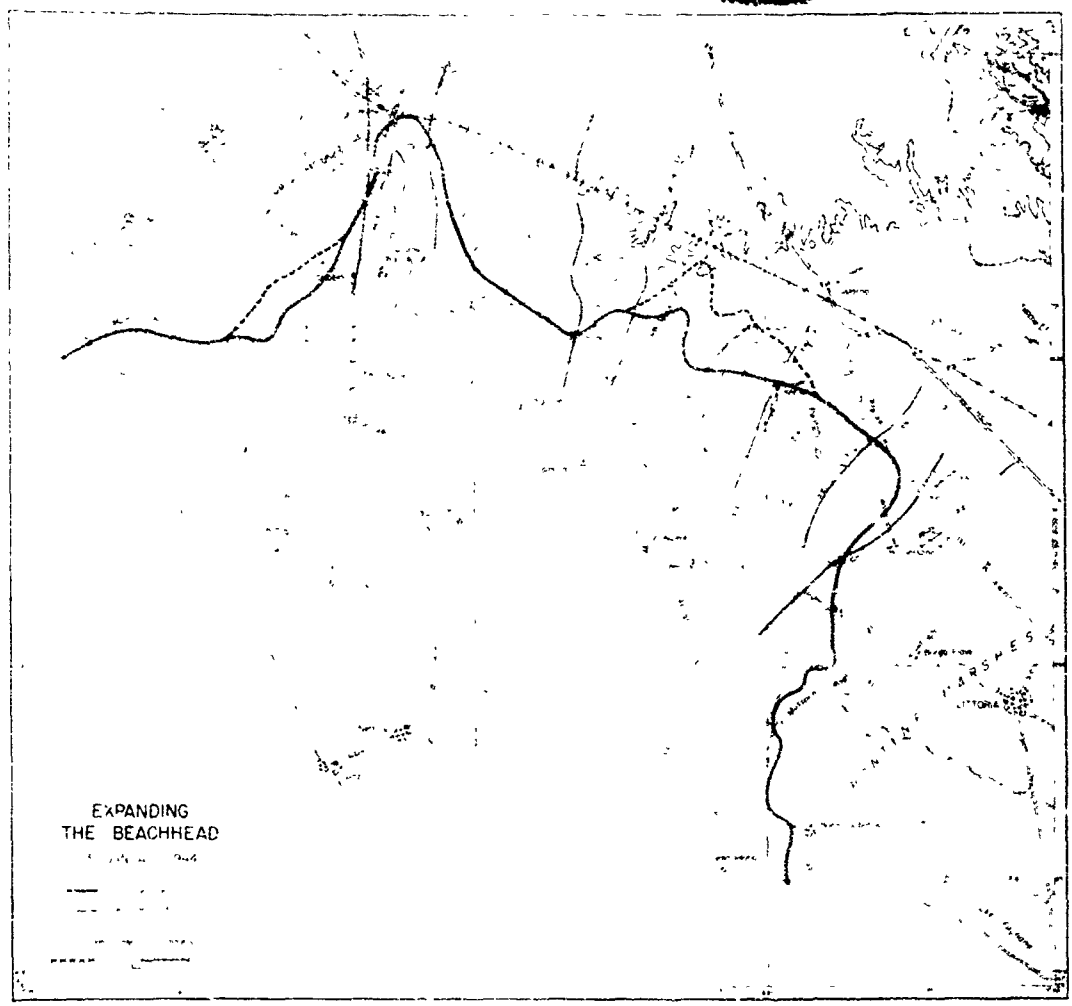

Map 6.—Expanding the Beachhead, 31 January 1944

The initial objectives of all three units were points on Highway 7.

The infiltration of the Rangers had been observed by the Germans and allowed to continue until practically the entire US force had entered the triangular area immediately south of Cisterna. The Germans occupied the houses along all 3 roads bordering the triangular area as well as dug-in positions. The force had been reinforced the preceding night in anticipation of a US attack on Cisterna. Suddenly and simultaneously concentrated hostile fire was delivered on the exposed Ranger personnel and there was no cover nor escape. Of the 767 Rangers attacked only 6 escaped. The 7th and the 15th Inf gained but one and one-half miles in the first day's attack. By noon of 1 February it was clear that the 3 divisions fighting on a 7 mile front toward an objective 3 to 4 miles away and exhausted by 3 days of bitter fighting, could not hope to take Cisterna in the face of ever-increasing enemy troops. They dug in, therefore, at Ponte Rotto

CAMPOLEONE STATION

While General Truscott on the right drove on Cisterna, the VI Corps made its main effort toward Colli Laziali along the Albano road.

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The plan provided for the British 1st Division to breach the enemy's main line of resistance by seizing the crossing at Compoleone (Map 6). The US 1st Armored Div was to wait until the British had taken the road junction at Osteriacci, 1,000 yards north of Campoleone, then a column of the 1st Armored Regt (minus the 3rd Bn but with the 3rd Bn 504th Parachute Inf, and the 27th Armored Field Artillery Bn attached) was to pass through the British and attack up the Albano road. The 1st Div would follow as quickly as possible. Meanwhile, the 6th Armored Inf with the 3rd Bn, 1st Armored Regt in support, was to seize the two and one-half miles along the railroad bed designated in the original order as the line of departure and then prepare to attack north.

The efforts of the 1st Armored and 1st Div to break through along the Albano road did not succeed. The 2nd Bn Sherwood Foresters and tanks of the 46th Royal Tanks fought their way across the railroad embankment at Campoleone but were stopped by the 29th Panzer Grenadier Regiment firmly entrenched in the houses lining the road from Campoleone to Osteriacci. The commander of the 3rd Brigade withdrew his infantry to allow tanks and artillery to soften up the German defenses. The light regiment (1st Bn, 1st Armored) and medium regiment (2nd Bn, 1st Armored) were unable to cross the railroad embankment because of severe enemy fire from the fortified houses some 300 yards beyond the railroad. The effort of the 1st Armored and 1st Inf Div to break through along the Albano road had not succeeded. While the drive on Campoleone was in progress, 2 battalions of the 6th Armored Inf together with supporting tanks were halted by extremely heavy small arms and antitank fire from Germans entrenched in farmhouses across the line of advance.

Thus the Allied attack had reached Campoleone and opened a 2-mile gap between the German 65th Infantry Division on the west and the 3rd Panzer Grenadier Division holding the center of the German line east of Campoleone. The Allied troops had driven 14 miles inland from Anzio to within 5 miles of Colli Laziali, but they lacked the strength to break through at Cisterna and Campoleone. The enemy had built up a strong system of defenses barring the approaches to Cisterna and Campoleone. Every house was converted into a strong point. Reducing each house was a small separate operation requiring tanks and tank destroyers to demolish the building be-

Figure 17.—DUKWs of the Fifth Army Coming Ashore

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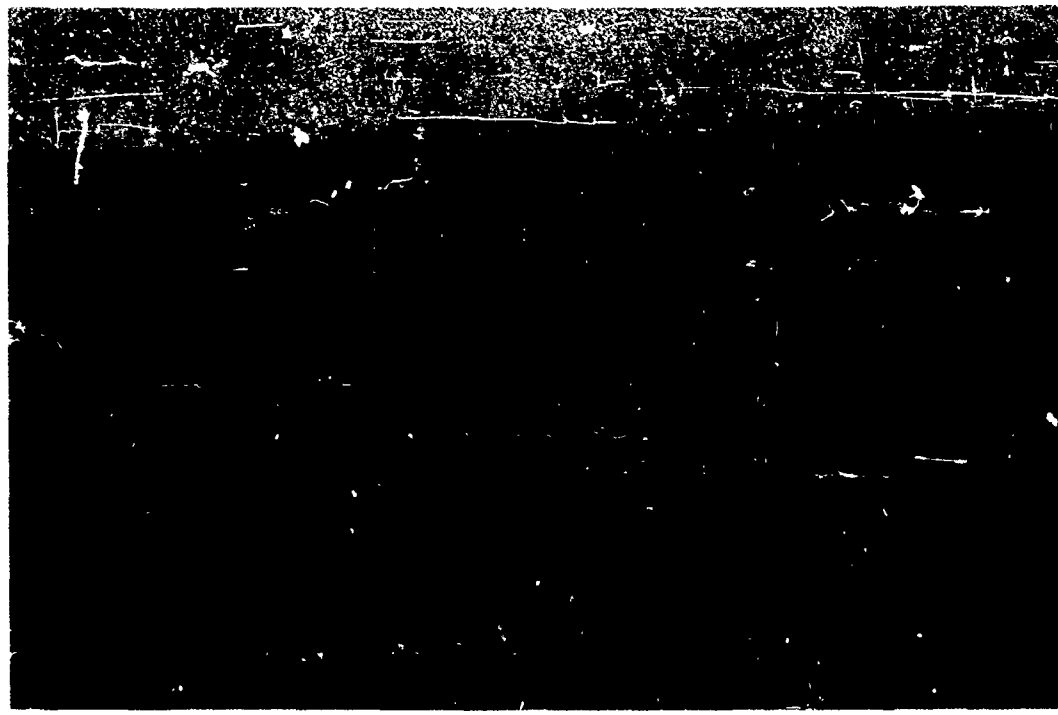

Figure 18.—An Ammunition Bunker, Anzio

fore the infantry could move in. Allied troops again found, as they had all through the Italian campaign, the excellent fortification value of the heavy stone construction of Italian farmhouses.

The VI Corps attack out of the beachhead had spent itself in the unexpectedly strong German defenses. It was expected that the enemy positions before Cisterna and Campoleone were merely delaying positions with the main line of resistance on the high ground of Colli Laziali and the Lepini Range. Instead the enemy, appreciating the value of these key road junctions and the limited strength of the opposing forces, determined to make a stand before Cisterna and Campoleone. Every house and village was converted into a strong point, and these were connected by well-camouflaged machine-gun nests and rifle pits. Allied troops further encountered massed artillery and Nebelwerfer fire in a way seldom employed by the Germans in Italy.

Every advantage of terrain lay with the enemy. On the left flank US armor proved incapable of surmounting the natural obstacles presented by rough streams and gullies and ground made soggy by repeated rains. On the right flank the route of advance lay over open muddy fields, offering scant cover to the attacker while providing excellent fields of fire for defending troops. January rains made ground movement difficult and low clouds during the crucial period of our attack severely hampered air support.

In anticipation of an enemy offensive, Allied reinforcements were brought to the beach, the VI Corps by 4 February numbering nearly 100,000 men, exclusive of service troops. The Germans were estimated to have 110,000 men. The enemy build-up had become so threatening that all units by 3 February had begun preparations of defensive positions to meet the expected German assault.

ALLIED USE OF AN ATOMIC BOMB

The Germans had planned a principal assault to be launched on 1 February southward along the Albano-Anzio road by Combat Group

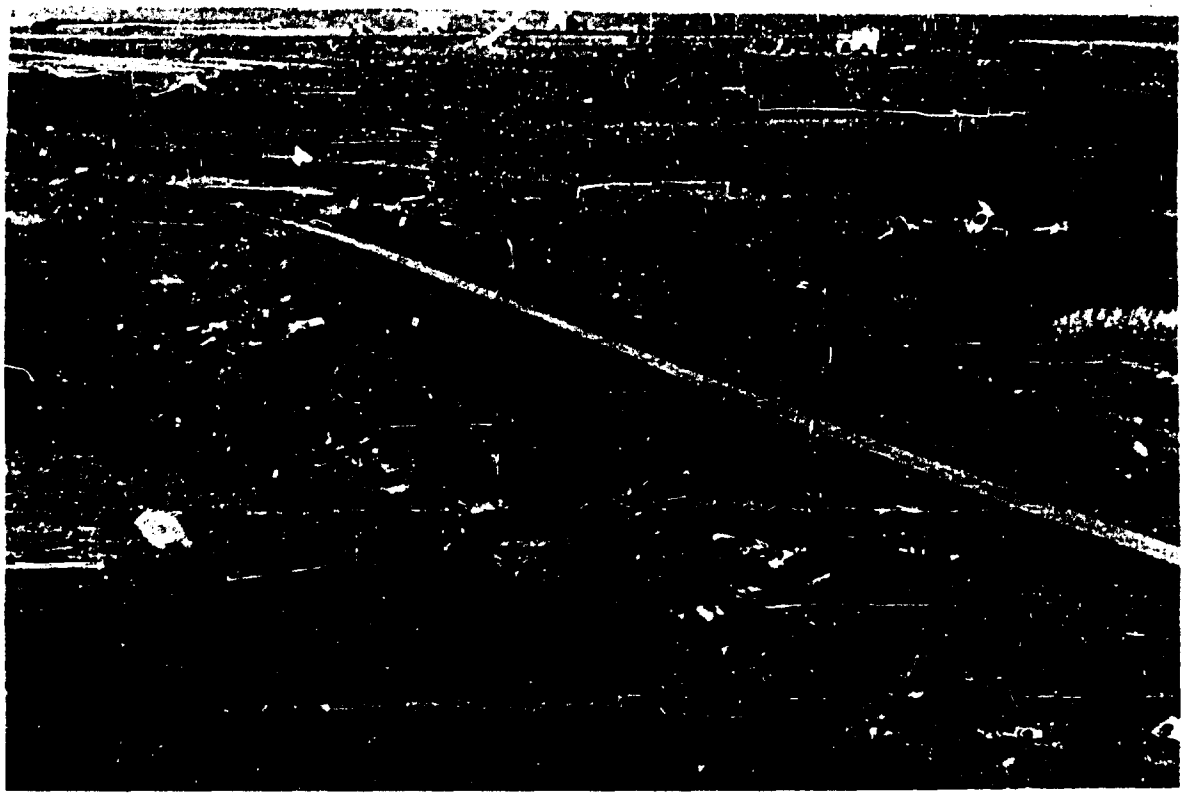

Figure 19.—An Aerial Shot of Allied Troops Dug in Along Mussolini Canal, 19 February 1941

Graeser which would consist of 17 infantry battalions heavily supported by artillery (Map 5). Thus, 17 of the German's 30 combat infantry battalions were distributed around the remainder of the 26-mile perimeter and 6 battalions were being held in reserve.

Assuming that 75 percent of these 17 battalions were in the open, and that the 17 battalions were on the average a mile and a half from ground zero (Station Campoleone), the troops in the open would have suffered 45 percent deaths and 53 percent hospitalizations, if the Allies had dropped an atomic bomb on the night of 31 January at Station Campoleone (Figure 14).

The way would then probably have been open for an Allied breakthrough and the objective of Field Order #20, namely the seizure of the high ground in the vicinity of Colli Laziali by the 1st Div, would have been achieved.

GERMAN USE OF AN ATOMIC BOMB

By the evening of 30 January the VI Corps had 6 infantry and 6 armored battalions in a narrow salient extending from south of the Factory (Aprilia) to Campoleone (Map 6).

Assuming that the 6 infantry battalions were in the open, the Germans, by dropping an atomic bomb in the vicinity of the Factory, would have killed 3,097 Allied soldiers and hospitalized 630 of the total Allied infantry strength of 5,400 men in the vicinity of the bomb burst.

Reference to Table X shows how these casualty figures were computed. The first column lists the battalions in the area on the evening of 30 January. The 6 armored battalions are assumed to be protected from the effect of an atomic bomb. The 6 infantry battalions, on the other hand, are assumed to be in the open and unprotected. They have an average strength of 900 men each, or a total infantry force of 5,400 men. The distance

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that each battalion would have been from a bomb dropped in the vicinity of the Factory was measured from Map 6 and is given in column 2 of Table X.

The percentage of deaths and hospital cases resulting from the dropping of the bomb can then be read from Figure 14 and the actual numerical values computed. (See columns 6 and 7 of Table X.)

By wiping out these infantry troops, the Germans might have been able to assume the offensive and drive the Allies from the beach in the next few days.

TABLE X
COMPUTATION OF CASUALTIES—ANZIO

	1	2	3	4	5	6	7
	ESTIMATED NUMBER PERSONNEL	ESTIMATED NUMBER IN OPEN	DISTANCE FROM GROUND ZERO	PERCENT DEATHS (U)	PERCENT HOSPITALIZATION (W)	NUMBER KILLED	NUMBER HOSPITALIZED
			yards				
2nd Bn—FOR Inf	900	900	4, 260	2 4	7	22	63
1st Bn—SG Inf	900	900	2, 030	92 5	7. 5	833	68
1st Bn—NS Inf	900	900	4, 190	2 5	8	23	72
5th Bn—GG Inf	900	900	2, 610	46 5	51	419	459
1st Bn—IG Inf	900	900	1, 670	98	2	882	18
6th Bn—Inf	900	900	730	100	0	900	0
1st Bn—1st Armd	700		3, 480				
2nd Bn—1st Armd	700		2, 730				
1 Bn 46th Royal Tanks	700		3, 480				
3rd Bn—1st Armd	700		3, 130				
1 Bn—Recce Armd	700		3, 100				
1Bn—6th Armd	700		2, 550				
Total						3, 079	680

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ENCLOSURE B
THE BATTLE OF CASSINO

by

Edward S. Gilfillan, Jr. and Grace Donovan

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THE BATTLE OF CASSINO

OBJECT

The object of this study is to determine whether or not either the Allies or the Germans could have made effective tactical use of an atomic bomb at Cassino.

CONCLUSIONS

Since the Germans were so thoroughly dug in as shown by the fact that they were able not only to survive but actually were in a stronger position following the exceedingly heavy bombing of 15 March in which 1,290 tons of high explosives were dropped by the Allies, it is very doubtful that the Allies would have been able to get sufficient enemy troops in the open to make effective use of the atomic bomb and secure the use of Highway 6 to Rome. On the other hand, the US troops were not well dug in and were concentrated in an area of less than 6 square miles so that it would seem that the Germans could on 12 February have eliminated all effective Allied resistance before Cassino by using an atomic bomb.

Note. It should be further kept in mind that uniforms specially designed to reduce the number of burns from the bomb flash are possible and very likely to be effective. The use of such uniforms has not been assumed here. Had this assumption been made, the computed casualties would have been much lower. Also, it has been calculated that fox holes offer very good protection from atomic bomb effects at distances from ground zero greater than 800 yards from ground zero. Finally, one should remember that the hypothetical weapons effects assumed here are grossly approximate and that, within wide limits, no one really knows what the effect of atomic bombs on troops would be. This study is merely an attempt to use the best available information to estimate the casualties to be expected—nothing more.

INTRODUCTION

The Italian campaign had been in progress for slightly more than 4 months when the US Fifth Army reached the Gustav Line about 15 January 1944. During the preceding period, Lt Gen Mark Clark's forces had driven the Germans from the beaches of the Gulf of Salerno, past Naples across the Volturno River, and through the Winter Line barrier of mountains. By the middle of January the enemy had withdrawn into the formidable Gustav Line behind the Garigliano and Rapido Rivers.

On 15 January 1944 this line was garrisoned by the XIV Panzer Corps with the 94th Grenadier Division spread thinly along the Garigliano, the 15th Panzer Division on the upper Garigliano and the Rapido to Cassino, the 44th Grenadier Division from Cassino 4 miles north to the village of Cairo, and the 5th Mountain Division on an 11-mile front to the northeast from Cairo before the FEC (Map 7).

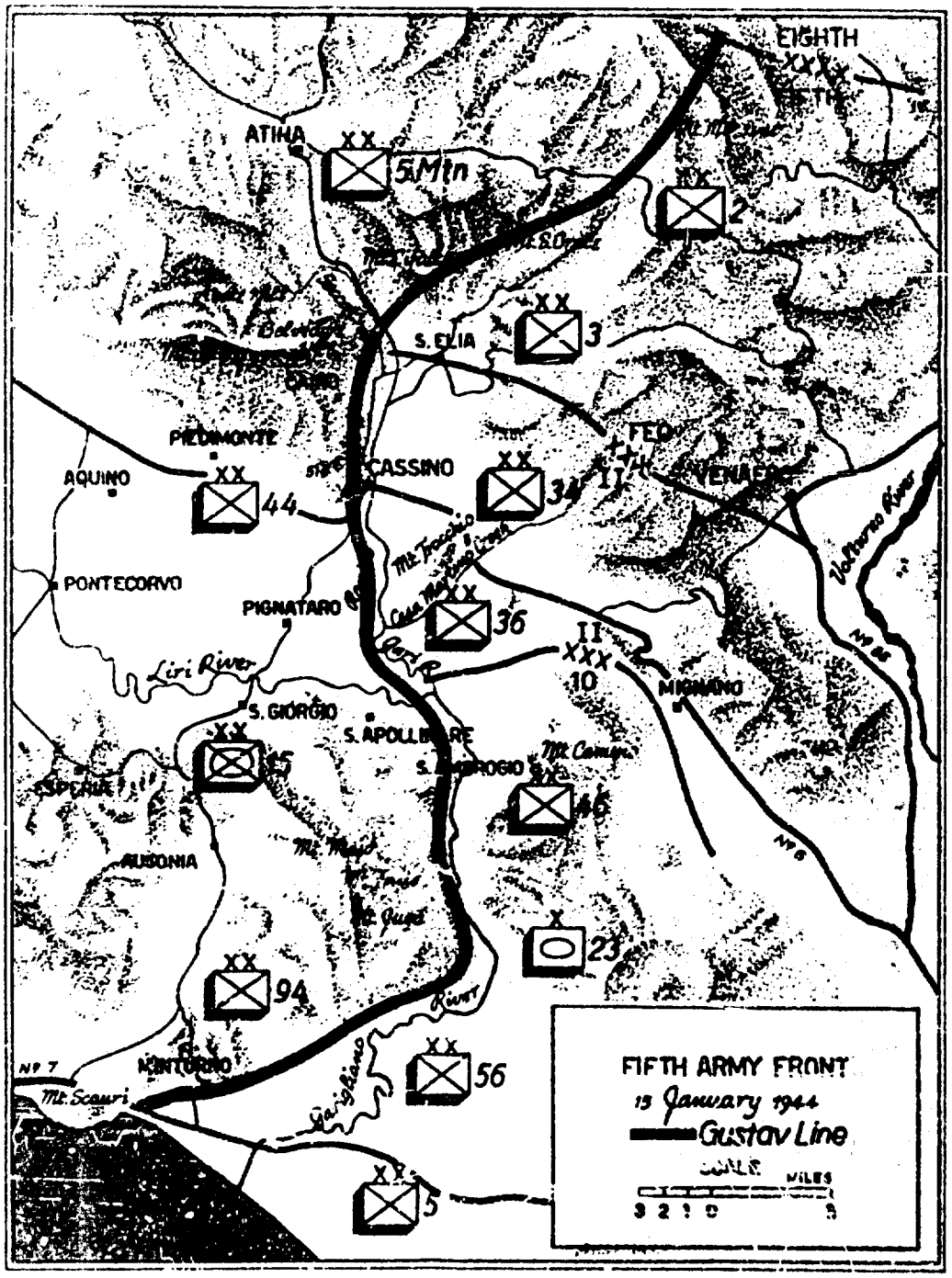
For reserves XIV Panzer Corps could draw on the 3rd Panzer Grenadier, Hermann Goering Panzer Parachute, and 29th Panzer Grenadier Divisions. Regrouping was under way behind the enemy lines to halt the advance of the Fifth Army; the 71st Grenadier Division came from Trieste to the 44th Grenadier Division sector in the center, arriving on the 17th of January, and the 90th Panzer Division was moving from the 8th Army front to bolster the Garigliano line.

The Fifth Army front at the beginning of the offensive against the Gustav Line extended more than 35 miles from the Tyrrhenian Sea to the Abruzzi National Park in the central mountain divide. Fifth Army had seven divisions and early in February got as reserve the New Zealand Corps made up of the 2nd New Zealand Division, the 4th Indian, and the British 78th Infantry Division. The Fifth Army could expect neither substantial US reinforcements nor reserves to be available to support the attack on the Gustav Line.

TERRAIN AND ENEMY DEFENSES [10]

Rivers and mountain masses make the terrain of the Gustav Line one of the most diffi-

[10] *History of the Fifth Army*, Part IV, pp. 5–8 (CONFIDENTIAL)



Map 7.—Fifth Army Front, 15 January 1944

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cult for *offense* in all Italy. In part the Gustav Line was based on watercourses and in part it took advantage of the mountain masses flanking the Liri Valley on both the north and south. The Rapido, Gari, and Garigliano form a continuous curving line from Mount Santa Croce on the north to the Tyrrhenian Sea on the south.

Beginning in the Fifth Army zone at Mount Marone, the Gustav Line ran southeast to Belvedere Hill (721 meters) and then south to Monastery Hill (510 meters) which was crowned by the Abbey of Monte Cassino that overlooked the city of Cassino. From the valley floor 40 meters above sea level at Cassino, the hills on the west side of the Rapido rise steeply to the great bulk of Mount Cairo (1,669 meters) four miles northwest to Cassino. Beyond Cassino the Gustav Line ran behind the Rapido and Gari to the Liri and west of the Garigliano through the rough and steep mountains centering at Mount Majo (940 meters) on to the sea at Mount Scauri.

The two principal routes leading into the area of the Gustav Line are Highway 7 along the coast and Highway 6 on the north side of the Liri Valley. A north-south road from Atina to Highway 7 follows the Secco and Rapido streams, passes through Cassino and then follows along the west side of the Rapido and Garigliano Rivers. All of this road south of Cassino was under German control although subject to our artillery fire. North of Cassino the road was under enemy observation and artillery fire. Most of it from Atina to the Rapido ran through enemy territory.

There were in general fewer and less carefully prepared defensive works at each end of the Gustav Line than in the center. On the north the mountains themselves were tremendous obstacles. Here the enemy followed the customary practice of siting many mortars and machine guns on the reverse slopes, while automatic weapons in well-camouflaged emplacements covered the forward slopes. Mine fields blocked natural avenues of approach and every trail was swept by machine guns.

Figure 20.—Cassino Area

The strongest portion of the line was known to extend from the village of Cairo south to Sant' Ambrogio on the Garigliano. Above Cassino the water of the Rapido had been diverted onto flat ground east of the river making the area too soft for armor. The approaches to the river were extensively mined. Bands of wire were stretched along the west bank and more mine fields were laid between the river and the mountains. Very carefully constructed emplacements were blasted and dug into the steep, barren slopes west of the river. *Large enough to contain living quarters for troops, these concrete and steel fortifications could withstand direct hits by artillery shells.* Concealed communication trenches led to machine-gun emplacements. Fields of fire were cleared and so inter-locked as to command all approaches from the east. Steep slopes seamed with deep ravines were numerous in the mountains north and northwest of Cassino; this terrain was thoroughly organized with wire, felled trees, concrete bunkers, and steel-turreted machine-gun emplacements. Observation posts in the mountains and in the abbey perched on Monastery Hill gave the enemy a perfect view of the approaches to the Rapido.

Cassino was more strongly fortified than any other city thus far encountered by the Fifth Army in Italy. Its stone buildings and narrow streets were admirably suited for defense. Snipers and troops with automatic weapons were garrisoned in strategically located buildings. Machine-gun emplacements, reinforced with concrete and steel railroad ties were concealed within the buildings. Self-propelled guns and tanks guarded every approach to the town and a series of hills and ridges provided close-in defenses behind the town. On the slopes of the hills were numerous machine-gun emplacements blasted out of the rock. The north-south roads from Cairo to Sant' Elia and Highway 6 from the south-

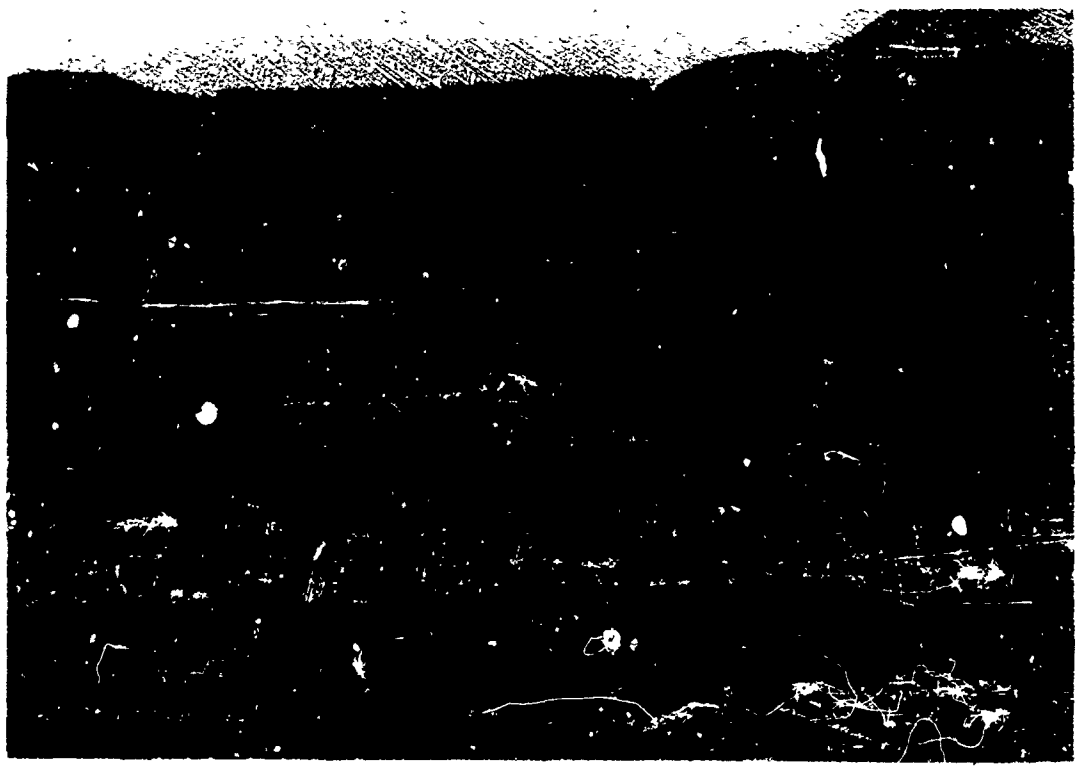

Figure 21.—View of Cassino, 6 February 1944

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Figure 22.—Interior of German Bunker Constructed of Three Feet of Reinforced Concrete on All Sides and Top, Roof Supported by 8 x 8 Inch Planks and Railroad Rails Inside and Outside of the Ceiling

east were mined and covered by artillery, mortar, and Nebelwerfer fire. The muddy plains to the east were thick with mines and wire.

Though lacking the advantage of Cassino, the Rapido line south to the Liri Valley was also thoroughly organized. Mines and wire guarded the approaches from the east. Other mine fields and more wire lay west of the river. Pillboxes and machine-gun emplacements in stone buildings covered the fortifications. Artillery and Nebelwerfers farther up the valley and defiladed in high ground on either side could cover nearly every foot of the river. South of the Liri River the Gustav Line was less strongly fortified than the Rapido sector. Here too there were extensive mine fields and wire barriers, steel pillboxes and concrete bunkers, but the enemy depended upon the mountains which he considered to be practically impassable to turn the scale against the Allied troops. Again, the reverse slopes were strongly organized while automatic weapons on forward slopes covered possible approaches.

The enemy, quick to shift reserves where most needed, could operate behind a mask of hills; nearly every daylight move by Allied forces toward the Garigliano could be observed by the enemy west of the river.

The Italians considered the area as an impregnable obstacle to any army attempting to capture Rome from the south. The Germans were determined to prove the validity of that assumption.

STRATEGY

The Fifth Army was to "make as strong a thrust as possible towards Cassino and Frosinone shortly prior to the assault landing (i.e., at Anzio) to draw in enemy reserves which might be employed against the landing forces (at Anzio) and then to create a breach in his front through which every opportunity will

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Figure 23.—One of the Crude Shelters Built by Soldiers Who Fought for Hangman's Hill near Monte Cassino

be taken to link up rapidly with the seaborne operation'[11] (Map 8). The 8th Army was to make what amounted to a holding attack to prevent the Germans from transferring divisions from the northern sector of the front to that opposite Fifth Army.

[11] Operations Instruction No. 32, General H. R. Alexander, 2 January 1944; reproduced in History of 5th Army, Part IV, Appendix A (CONFIDENTIAL).

Thus, as a result of the decision to land on Anzio, the Fifth Army was committed to a strong attack on the Gustav Line at once. General Clark's plans for the attack were issued on 10 January, the schedule being:

12 January—FEC drive on enemy's left toward Sant' Elia.

15 January—II Corps drive in the center to take Mount Trocchio.

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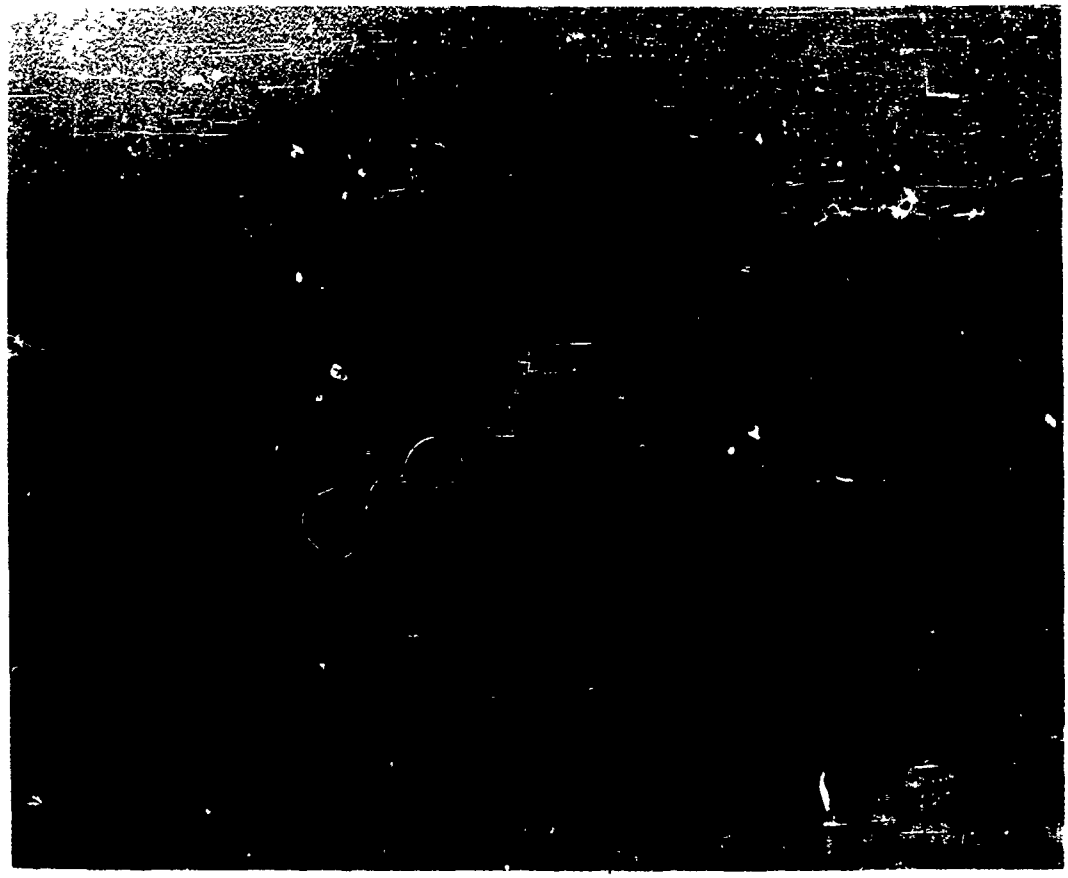

Figure 24.—During the Artillery Bombardment of Cassino the Cassino Castle on the Small Hill in the Foreground and the St. Benedictine Monastery on the Summit Above Were Unharmed by American Shelling, 6 February 1944

17 January—X Corps attack to envelop the enemy's right by crossing the Garigliano in the Minturno area and pushing rapidly north toward San Giorgio. Simultaneously X Corps was to establish a second bridgehead at Sant' Ambrogio to protect the left flank of the II Corps.

18 January—II Corps frontal assault over the Rapido in the vicinity of Sant' Angelo in Teodice.

22 January—VI Corps landing at Anzio to threaten enemy's rear.

The French (FEC) forced the Germans to evacuate Sant' Elia on 15 January; the II Corps captured Mount Trocchio on the same day. The British X Corps attempted the crossing of the Garigliano River on 17 January. By 8 February the X Corps bridgehead across the Garigliano had reached its limit. The outer defenses of the Gustav Line had been breached and the 46th Div of the X Corps had captured about 6 square miles northeast of Castleforte. When the 56th Div was summoned to reinforce the Anzio beachhead, the plan to drive up the Ausonia Valley was abandoned and the X Corps went on the defensive. The bridgehead was to prove invaluable in the May drive but it was of little immediate value in breaking the Gustav Line (Map 9).

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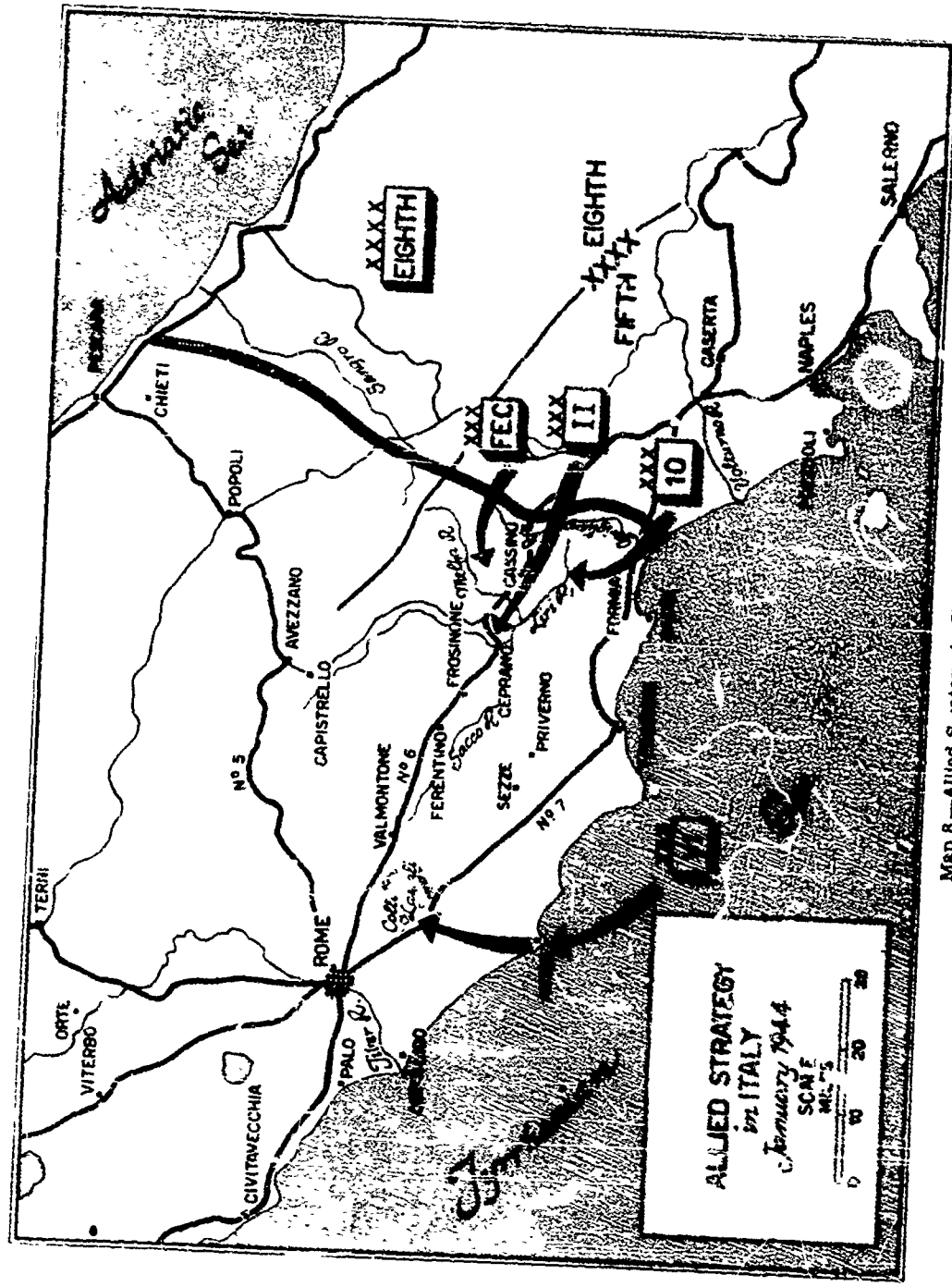

Map 8.—Allied Strategy in Italy, January 1944

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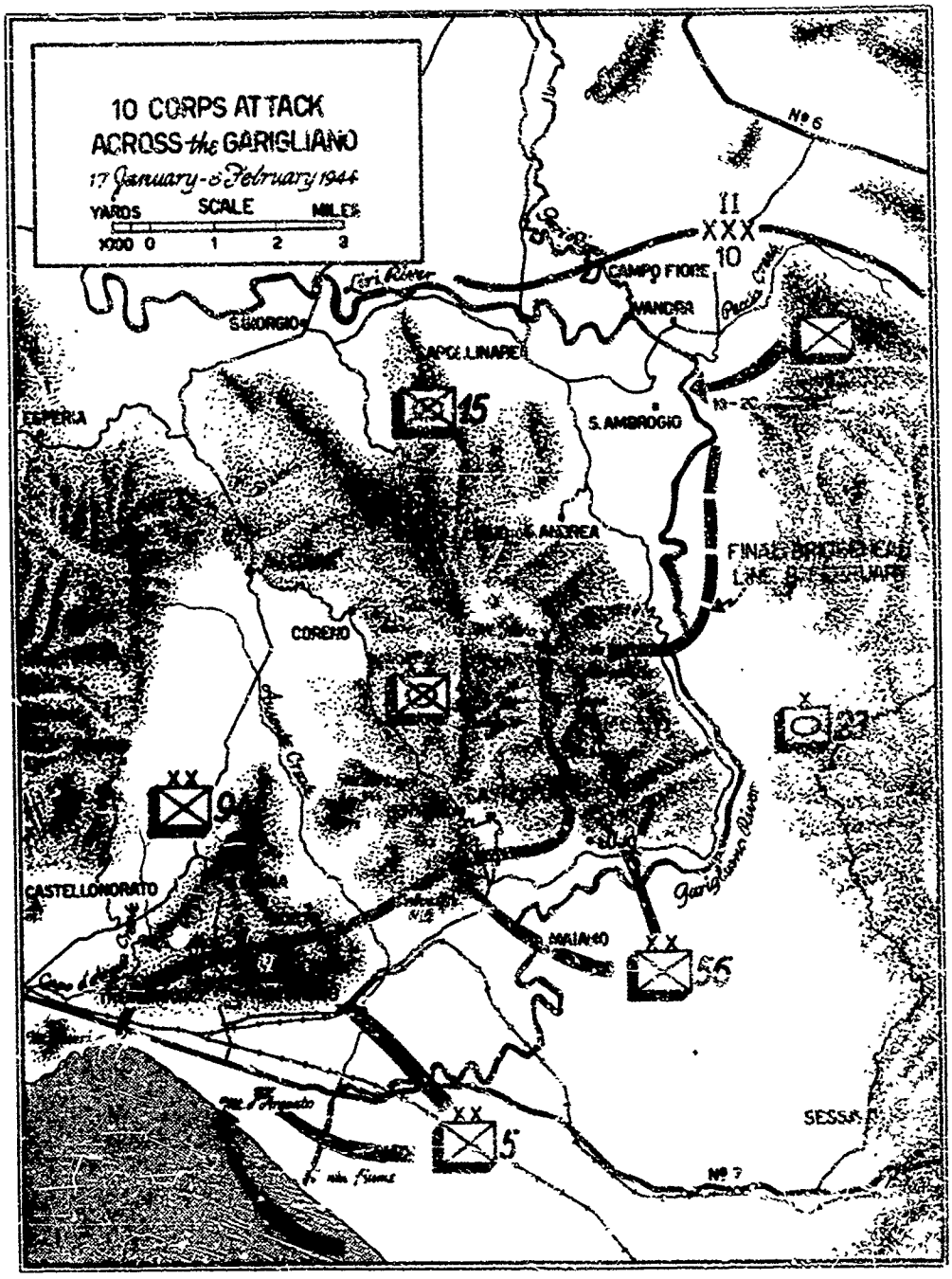
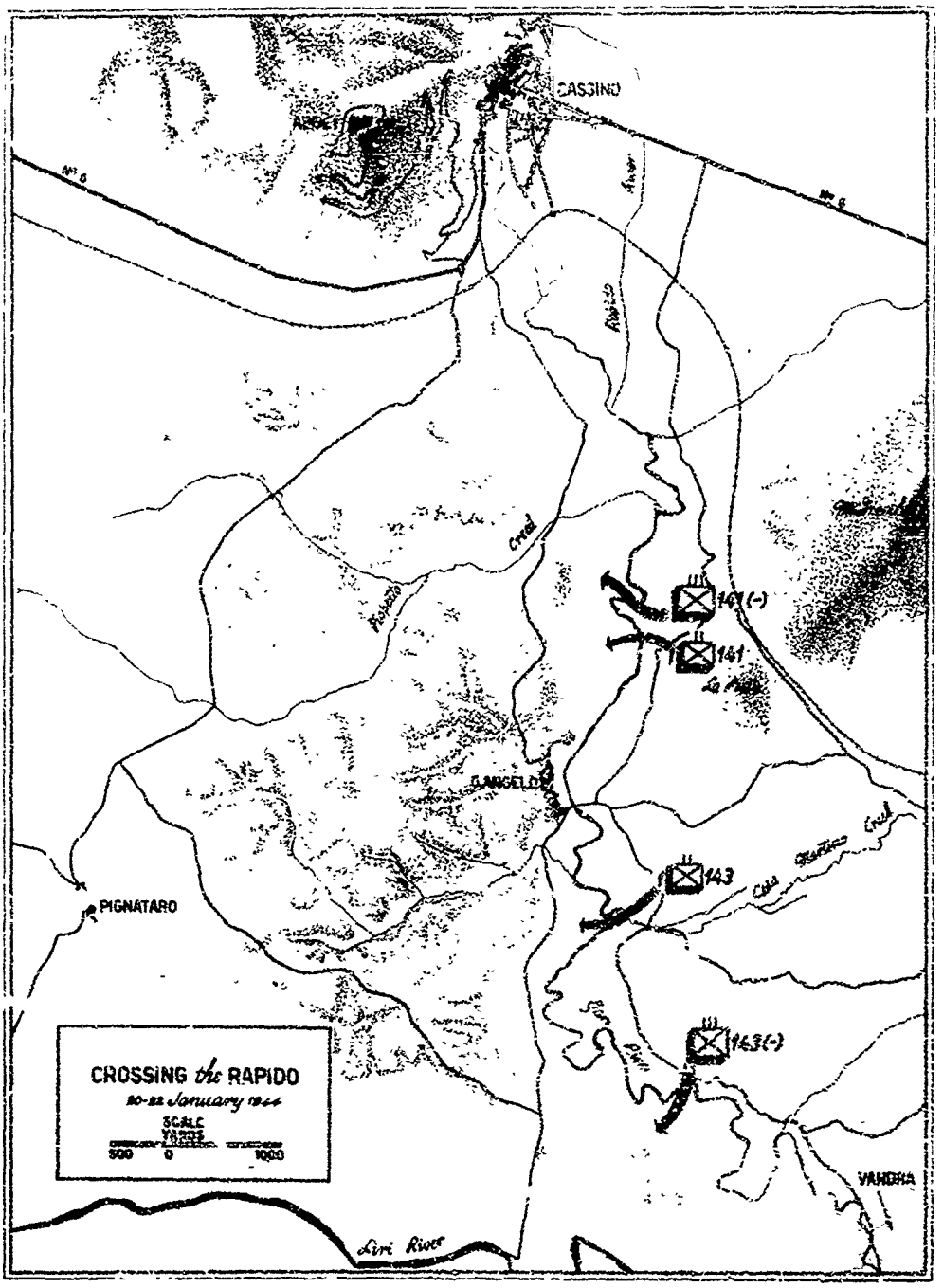


Map 9.—10 Corps Attack Across the Garigliano, 17 January–8 February 1944



Map 10.—Crossing the Rapido, 20-22 January 1944

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THE 36TH DIVISION AT RAPIDO

The 36th Div was to carry on the principal mission of the II Corps by establishing a bridgehead in the Sant' Angelo area as far west as Pignataro (Map 10). Then, on Corps' order, Combat Command B of the 1st Armored Div was to pass through the bridgehead and attack toward Aquino and Piedimonte. The 91st Cav Rcn Sq was to screen the left flank during this exploitation. On the Corps' right flank the 34th Div was to demonstrate in conjunction with the attack of the 36th Div to hold the enemy on the Cassino front. The 34th Div was also to prepare plans to attack Cassino from the east or from the south through the Sant' Angelo bridgehead, or to pass through the 36th Div to continue the Corps' effort on the northwest. In brief, the plan called for a wide envelopment *south* of the Cassino position.

The Rapido River south of Highway 6 is a narrow but swift stream. Varying in width from 25 to 50 ft, it flows between nearly vertical banks 3 to 6 ft high. In January the water was from 9 to 12 ft deep. Sant' Angelo is built on a 40-ft bluff above the west bank about midway between Cassino and the Liri-Gari junctions. This bluff slopes to the north and south; there are no bluffs on the east side of the river. The town, therefore, gave the Germans observation over much of the river and a large area to the east. Observation posts in the Abbey of Monte Cassino provided perfect coverage for the area between Mount Trocchio and the Rapido. Prior to the crossing no rain of consequence had fallen for approximately 10 days but previous continued rains had so soaked the entire area that the flat areas which stretched on both sides of the Rapido River from 2 to 600 yards were soggy and impassable for track laying vehicles in large areas near the stream. During the period 20–24 January heavy dense fog covered the Rapido Valley during most of the night, during the morning, and during the early afternoon. After 1400 the fog thinned somewhat and by 1600 visibility had reached 700 to 800 yards. A short time after sundown the fog closed in again.

The 141st Regt and the 143rd Regt attempted the crossing on the night of 20–21 January and again on 21–22 January. On the first attempt 2 companies from the 1st Bn of the 141st Regt and the 1st Bn of the 143rd Regt crossed to the west bank but had to withdraw because of heavy casualties. In the second effort, the 143rd Regt succeeded in getting 2 companies of the 1st and 2nd Bn across and the 3rd Bn, and the 141st got the 3rd Bn across but by 1900 of 22 January, only forty men from the Fifth Army returned to the east side, all the rest having been killed, captured, or wounded.

The strength of the two regiments of the 36th Div taking part in this attempted crossing and their losses are shown in Table XI.

The crossing on the night of 20–21 January was preceded by heavy artillery fire from the 133rd FA Bn, 132nd FA Bn and 68th FA Bn giving close support to the 143rd Regt and 12 other battalions from division artillery and Corps firing in the area on time schedule but in general support of the division operations. Companies B and C, 2nd Chemical Bn were used to thicken the fire of artillery.[12]

By 20 January the enemy forces in this area were:

104th Panzer Grenadier Regiment—from Highway 6 to a short distance south of Sant' Angelo;

[12] 143rd Regt (36th Div)—Operation in Italy—January 1944.

TABLE XI
36TH INF DIV—OPERATION IN JANUARY 1944

	141ST REGT			143RD REGT		
	O	Wo	EM	O	Wo	EM
Total present duty 1 January 1944	230	5	3,549	207	5	3,583
Losses, battle casualties	52	0	1,007	46	0	919
Losses, non-battle casualties	21	0	507	13	1	586
Present for duty 31 January 1944	157	5	2,032	147	4	2,074

115th Reconnaissance Battalion—on right of 104th Regiment, opposite Cosa Martino Creek:

1st Battalion, 129th Panzer Grenadier Regiment in the pocket between the Gari and Liri Rivers;

211th Grenadier Regiment—southwest of Piedimonte in reserve.

By the evening of 21 January the enemy had brought up these reinforcements from the rear:

211th Grenadier Regiment—between Highway 6 and Piopeto Creek;

3rd Battalion—104th Panzer Grenadier Regiment south of Sant' Angelo;

115th Reconnaissance Battalion side slipped with the Liri-Gari pocket.

The attack had been a costly failure. Inability to follow through with strong reinforcements and supplies, lack of visibility for more effective artillery fire on enemy counterattacks, and disruption of communications by hostile fire were all contributing factors for the failure, but the *main reason for failure was the enemy's extremely strong and expertly defended fortifications west of the river.*[13]

THE 34TH DIVISION AT RAPIDO 24–29 JANUARY

By 22 January, the tactical situation required that Fifth Army modify its plan to break into the Liri Valley. General Clark therefore directed that II Corps attempt to envelop Cassino from the *north*. The FEC was to change the direction of its advance and turn southward toward Terelle and Piedimonte. This shift would throw the weight of the FEC to its extreme left and might weaken the Cassino defenses by developing a threat to the enemy's lines of supply and communications. On the left of the French, the 34th Div (Map 11) would cross the Rapido and advance south, sending one column down the road into Cassino while the other forces went through the mountains to take high ground dominating the town and debouch to the enemy's rear near Piedimonte.

Defensive positions were similar to those guarding the Rapido River south of Cassino with the additional advantage of bal advantage of barren, rough, and step mountains overlooking ountains overlooking all approaches to the Rapido. The entire Rapido. The entire plain soggy from heavy rains was impassable ains was impassable for armor except by the construction of co construction of corduroy roads. Many irrigation and drainage di ation and drainage ditches, extensive mine fields on each side of the ds on each side of the river, and barbed wire added greatly to th added greatly to the infantry's difficulties. Once across the R Once across the Rapido, the troops would face a line of pillboxes ce a line of pillboxes, dugouts, and reinforced stone houses alon d stone houses along the base of the mountain from Hill 213 to Ca in from Hill 213 to Cassino. From these positions the enemy had fie ns the enemy had fields of fire which completely covered the rive ely covered the river flat.

The 133rd Inf was to capture Hills 5 as to capture Hills 56 and 213, the barracks area and the road to C rea and the road to Cassino south of the barracks. It was to be rein ks. It was to be reinforced by the 756th Tank Bn, the 937th FA Bn Bn, the 937th FA Bn, and Company D, 2nd Chemical Battalion. Chemical Battalion. The 135th Inf was to maintain direct press aintain direct pressure on Cassino and be prepared to attack C repared to attack Cassino from the north. The 168th Inf was to the 168th Inf was to occupy an assembly area 1 mile east of the ba mile east of the barracks during the nights of 24-25 January, pr of 24-25 January, prepare to pass through the 133rd and go on the 133rd and go on to capture the division objectives, Mount Cast jectives, Mo nt Castellone, Sant' Angelo Hills, and Albaneta Farms and Albaneta Farms.

All 4 of the division field artillery batt on field artillery battalions plus a battalion of 155mm howitzers of 155mm howitzers from Corps Artillery (937th) fired a 30-m 937th) fired a 30-minute preparation, aided by the 3 cannon com by the 3 cannon companies and the 805th Tank Destroyer Battalion k Destroyer Battalion.

The 133rd succeeded in getting the 1st ded in getting the 1st, 3rd, and 100th Bn across by 26 January but as by 26 January but all had to withdraw to the opposite bank sin e opposite bank since no armor succeeded in getting across to su getting across to support them. The 168th Inf th n passed th Inf then passed through the 133rd and made the main effort on 25 the main effort on 27 January assisted by the 756th Tank Battal e 756th Tank Battalion.

By 0915, 27 January only 4 tanks uary, only 4 tanks of the 756th Tank Bn succeeded in crossing ceeded in crossing to the west bank of the river (the 756th Tan river (the 756th Tank Bn had 54 medium and 17 light tanks a ull 17 light tanks available) but were out of action by 1300. Two we on by 1300. Two were destroyed by enemy rocket grenades, one rocket grenades, one suffered a broken track when it hit a mine k when it hit a mine, and the fourth stuck near the crossing near the crossing when it returned for more ammunition. Yet the mmunition. Yet the tanks had succeeded in clearing lanes for the clearing lanes for the infantry. By dawn of 28 January 2 pla of 28 January 2 platoons

[13] History of the Fifth Army, Part IV p 48 (CONFIDENTIAL).

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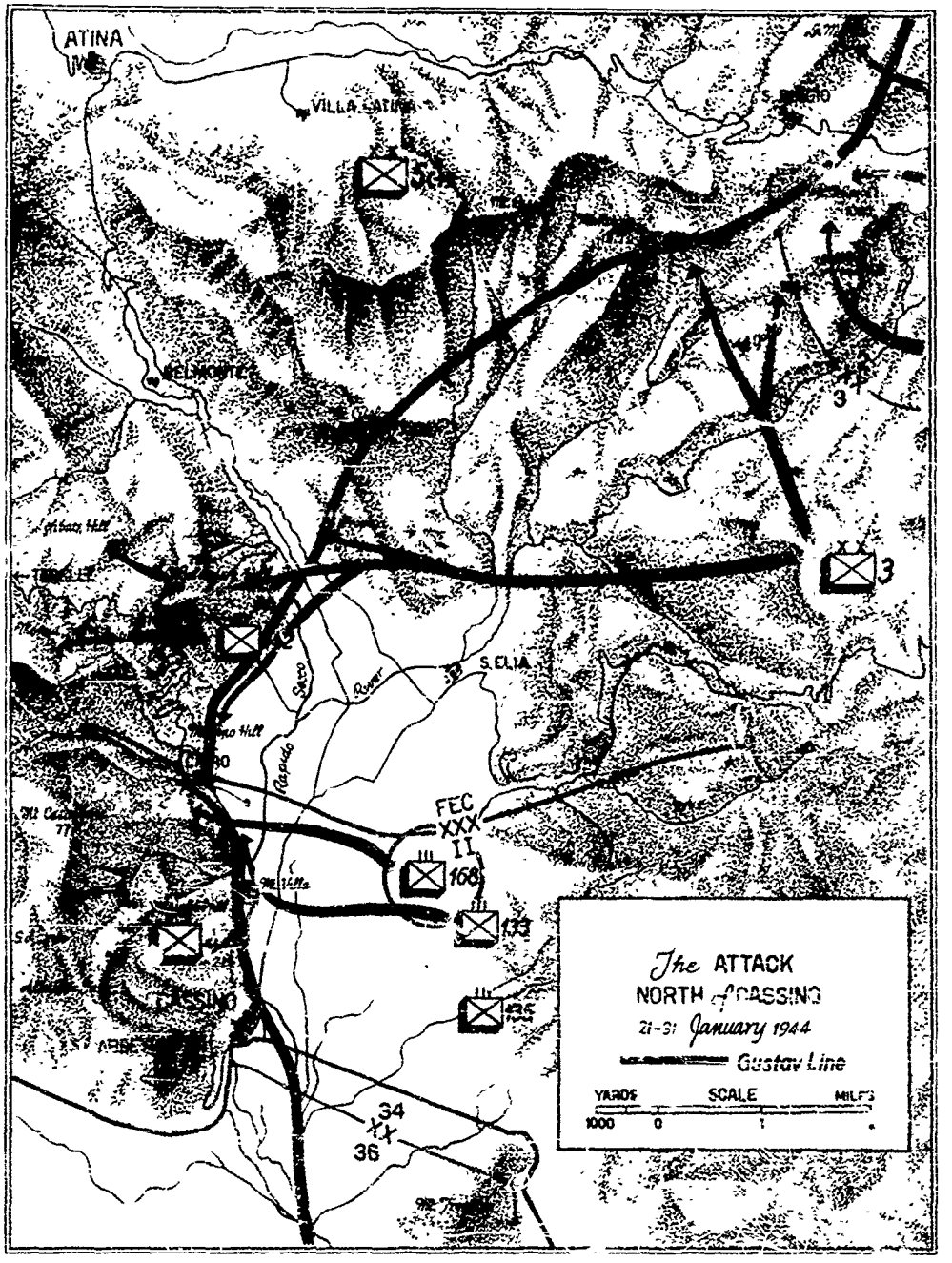

Map 11--The Attack North of Cassino, 21-31 January 1944

from the 168th Inf were dug in midway between Cairo Village and the Rapido.

A combat team was formed to renew the attack on 29 January. One company and 1 platoon of the 760th Tank Bn were added with the 175th FA Bn in direct support. All of the Corps engineers (235th Engineer Bn and 1108th Engineer Group) were in support. The 2nd Bn, 168th Inf, was to make the main effort toward the saddle between Hills 56 and 213. One company of tanks was to precede the infantry. On the left the 1st Bn and a platoon of tanks were to take Hill 56, while the 3rd Bn with another platoon of tanks would advance to the north of Hill 213.

The plan succeeded. The 756th Tank Bn played a decisive role in forcing the issue when 23 tanks coming down the dry river bed from the Corps' boundary turned west at about 1600, 29 January. The infantry then struck the battalions in columns following in the tank tracks and by 1845 all 3 battalions of the 168th were at the base of Hills 56 and 213. The 2nd and 3rd Bn captured Hill 213 before dawn on 30 January and the 1st Bn took Hill 56. By 1130 a platoon of Company K aided by a platoon of tanks captured Cairo Village and with it the headquarters of the 131st Grenadier Regiment.

The 168th Regt met opposition from the German 44th Division. It was learned that the 132nd Infantry Regiment (German) had been in position on Hill 213 down to the town and that the 131st Infantry Regiment (German) had been in Cairo and to the north.

The 168th Regt remained in defensive positions on 31 January, 1–2 February while the 135th Inf Regt and the 133rd Inf Regt exploited the break which it had made in the Gustav Line.

It seems evident that if the German defenses had been strong enough to hold off the tanks, the attack could not have been made. As a tank obstacle the Germans were depending upon an area flooded by the diversion of the Rapido River. But US engineers had been able to construct a tank crossing further north in the bed of the Rapido River which the Germans had dried up by destroying the dam. By blowing up part of the river bank by the dam and another dam further down stream, the river bed made an excellent tank approach.

The strength of the 34th Div that made this crossing to the north of Cassino was:[14]

	24 January	*31 January*
168th Regt	3,291	*2,815
133rd Regt	4	
(1st and 3rd Bn)	2,430	2,143
100th Bn	832	574
135th Regt	3,226	3,682
	9,829	8,614

* 1 February.

THE FEBRUARY DRIVE ON CASSINO, 1–12 FEBRUARY

TERRAIN AND ENEMY DEFENSES

At the beginning of February the tactical situation on the southern front was fairly clear from the enemy's point of view. Attacks by the Fifth Army revealed the plan to turn each flank in order to pave the way for a breakthrough in the Liri Valley. The critical points were Sant' Ambrogio and Castleforte areas south of the Liri and the hills around Cassino.

In this region the mountains rise abruptly from the valley floor which has an elevation of about 40 meters above sea level. Four miles to the northwest of Cassino, Mount Cairo rises 1,670 meters (5,500 ft) above sea level. About half of this district extending more than 2 miles west and 3 miles north of Cassino was the scene of some of the bitterest battles fought during the Italian campaign. *This small area of 6 square miles held the enemy's forces defending Cassino and the northern entrance to the Liri Valley.* Mount Castellone (771 meters) and Sant' Angelo Hill (575 meters) marked the western limits of the Cassino defenses. The greatest enemy strength lay south of Majola Hill near the center of the district. Monastery Hill (Hill 516), and more than a dozen hills and knobs close to it, dominated the town. Hill 593, about one-half mile to the northeast, was the outer bastion of Monastery Hill in that direction. This in itself was protected by Sant'

[14] History 168th Inf Regt, 34th Inf Div January 1944; History 133rd Inf Regt, 34th Inf Div January 1944; History 135th Inf Regt, 34th Inf Div January 1944.

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Angelo Hill and Majola Hill. The ridge running northwest to Cassino had three important points, terminating in Castle Hill (Hill 193) on the western outskirts of the town. Hangman's Hill (Hill 435) three-fourths of the way up the southwestern slopes of Monastery Hill was another key point

There is practically no timber in this area. Some slopes are terraced; cultivated fields occupy some of the narrow valleys; and deep ravines are numerous. The few trails winding among the mountains could easily be covered by machine-gun fire. All positions were mutually supporting, protected by mine fields, and strongly fortified. This terrain and the enemy's use of it gave him an all but impregnable fortress. Nevertheless, the Fifth Army had to attack to force its way into the Liri Valley and the attack had to be made by troops already near the point of exhaustion after several weeks of hard fighting.

Enemy troop movements brought added strength to these positions. The 211th Grenadier Regiment reinforced by the 132nd Grenadier Regiment was responsible for Cassino itself. The 134th and 131st Grenadier Regiment, the 191st Grenadier Regiment and the 8th Panzer Grenadier Regiment held the rest of the sector from south to north.

FIFTH ARMY ATTACK

General strategy of the II Corps drive on Cassino remained unchanged in February. The 34th Div continued its thrust from the north and Combat Command B of the 1st Armored Div prepared detailed plans for deployment into the Liri Valley if Cassino fell.

The 1st Tank Gp attached to the 34th Div had the mission of spearheading the Liri Valley drive and supporting the infantry with fire and movement.[15] The 756th Tank Bn was assigned to support the 133rd Inf Regt advancing south from the barracks; the 753rd Tank Bn was to support with fire from the east, then move into Cassino; the 760th Tank Bn, most of which was attached to the 36th Div, planned to advance through Cassino to seize the highway south of the town.

During preparatory fire preceding the infantry attack on 1 February, elements of all 3 tank units were to advance to positions immediately around Cassino to provide close-in fire on enemy strongpoints

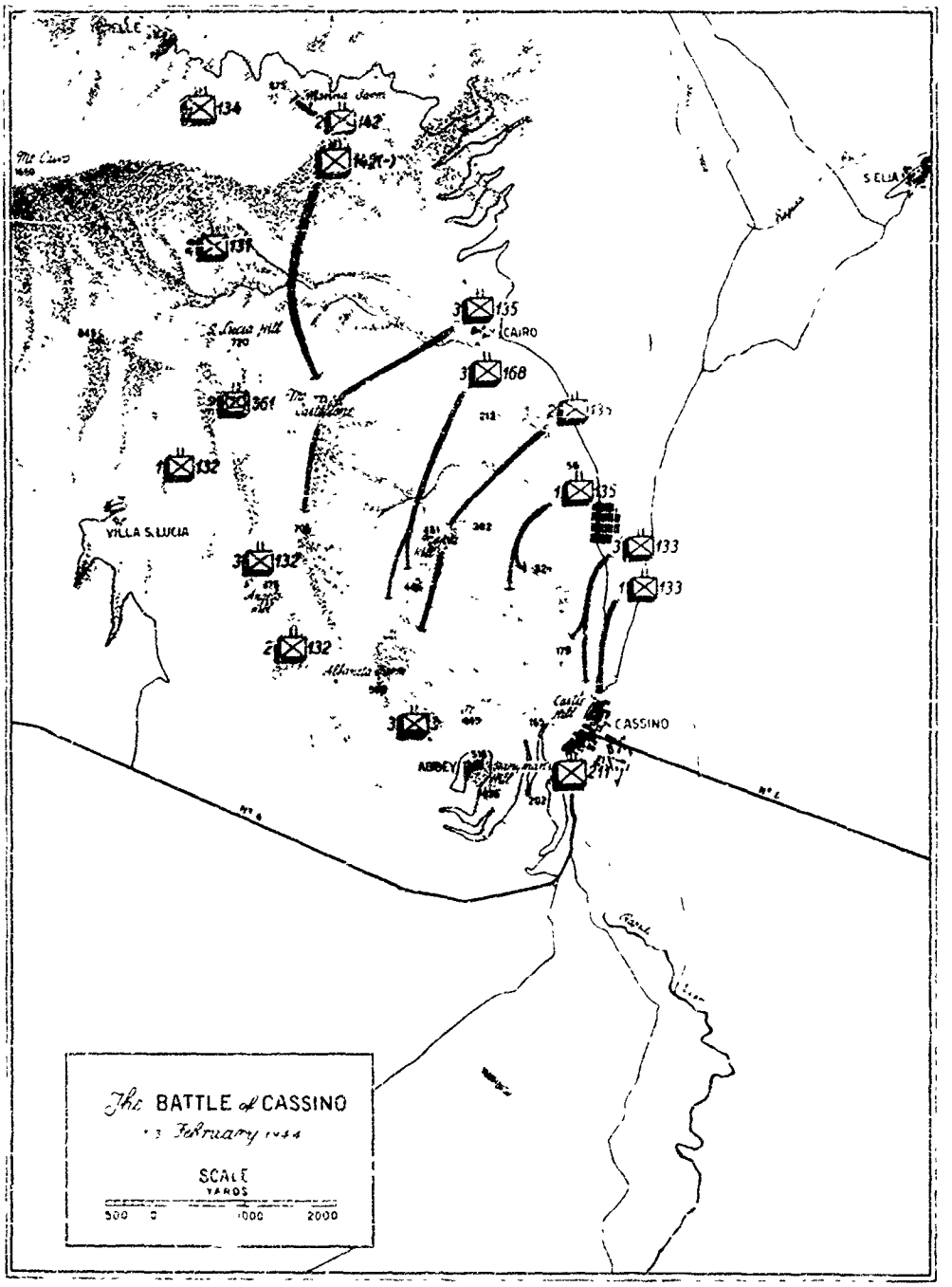
The 34th Div made important gains in the first three days of the February drive (Map 12). Approximately one-third of the critical area northeast of Cassino was in its hands and both infantry and tanks had won a slight foothold in Cassino itself. But the closely-packed fortifications of Cassino and Monastery Hill stood as one of the most formidable enemy strongpoints yet encountered by Fifth Army troops. Three main drives in the next nine days failed to produce the breakthrough to Highway 6 about a mile away. The extremely bitter fighting had reduced the combat efficiency of the 34th Div to a critical point.

The 36th Div which had been relieved south of Highway 6 by the 2nd New Zealand Division on 6 February moved around to the right of the 34th Div in preparation for a capture of Piedimonte from the northeast. The 143rd Inf assembled in the vicinity of Cairo on 6 February, the 141st at Ciccerelle and the 142nd at Castellone. The division had as its immediate objectives the capture of Albaneta Farm, Hill 374, and Hill 593. An attack on 11 February did not succeed, and after repelling an unusually persistent counterattack, the division by 13 February passed over to the defensive. The 36th Div, after its losses on 20–22 January, was more than 3,000 infantrymen understrength.

Heavy losses had been suffered by the enemy but his ability to rush reinforcements forward to meet the Fifth Army thrusts had been decisive. Although there was little discrepancy in numbers between the opposing forces, a numerically inferior force in such strong mountain defenses still would possess a great advantage.

By 17 February, the II Corps was exhausted and relinquished the battle to the New Zealand Corps, all but one US battalion being relieved by the end of February.

[15] In addition to the armor, the 1st Tank Gp on 1 February comprised the 776th Tank Destroyer Bn; 596th Armored FA Bn, Company C, 48th Engineer Combat Bn, and Troop B, 91st Cav Reconnaissance Squadron.



Map 12—The Battle of Cassino, 1-3 February 1944

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POSSIBLE USE OF AN ATOMIC BOMB BY THE GERMANS AGAINST THE FIFTH ARMY ON 12 FEBRUARY 1944

On 12 February the Fifth Army had 2 divisions along a 3-mile front in an area of 6 square miles (see Map 13).

The exact position and strength of each regiment was as follows:

34th Division

168th Regt

1st and 3rd Bn—in position of Hills 445 and 450.

2nd Bn—In defensive position in the vicinity of Hill 593. A provisional rifle company was formed on 10 February under command of the commanding officer of the antitank company from 7 men from Hq Co, 8 from antitank and 15 returned from the hospital. The company on 11 February went to Mount Majola and were held in reserve.

Strength: The effective strength of the rifle companies on 10 February was: 1st Bn—154; 2nd Bn—393; and 3rd Bn—246. During the night of 10 February, extra drivers of the 3rd Bn were attached to Company K and the antitank platoon and extra drivers and clerks of 1st Bn were attached to Company B. The effective strength of the regiment was reported to be 1,923 men on 12 February. (See Table XII for sample of effective strength report.)

133rd Regt

1st and 3rd Bn—in west half of Cassino with the 1st Bn on the left flank of the 3rd

2nd Bn—(100th Inf)—in regimental reserve in the vicinity of Hill 165.

Strength: 2,317 men

135th Regt

1st Bn—On right of 2nd Bn to the northwest of Hill 445

2nd Bn—Had dropped slightly back from Hill 593 being relieved on Hill 593 by elements of the 168th but still in position to support the attack of the 168th Inf and 141st Inf by fire and move on Hill 593 after all enemy elements had been cleared from the Hill.

3rd Bn—Precarious hold on point 445.

Strength By the end of 4 February some rifle companies were down to 50 percent of fighting strength The 3rd Bn alone had suffered 165 casualties in the first four days of February. The fighting strength of the regiment was sapped as a result of constant, sustained fighting for a period of 48 days. The rifle companies had an average strength of 50 men with some down as low as 30 men present for front line duty, 688 casualties were suffered from 1–14 February so that on 12 February, there were approximately 2,394 men in the regiment.

Thus the whole 34th Div has an effective strength on 12 February of approximately 6,500 men.

36th Division

141st Regt

1st Bn—Vicinity of Hill 593.

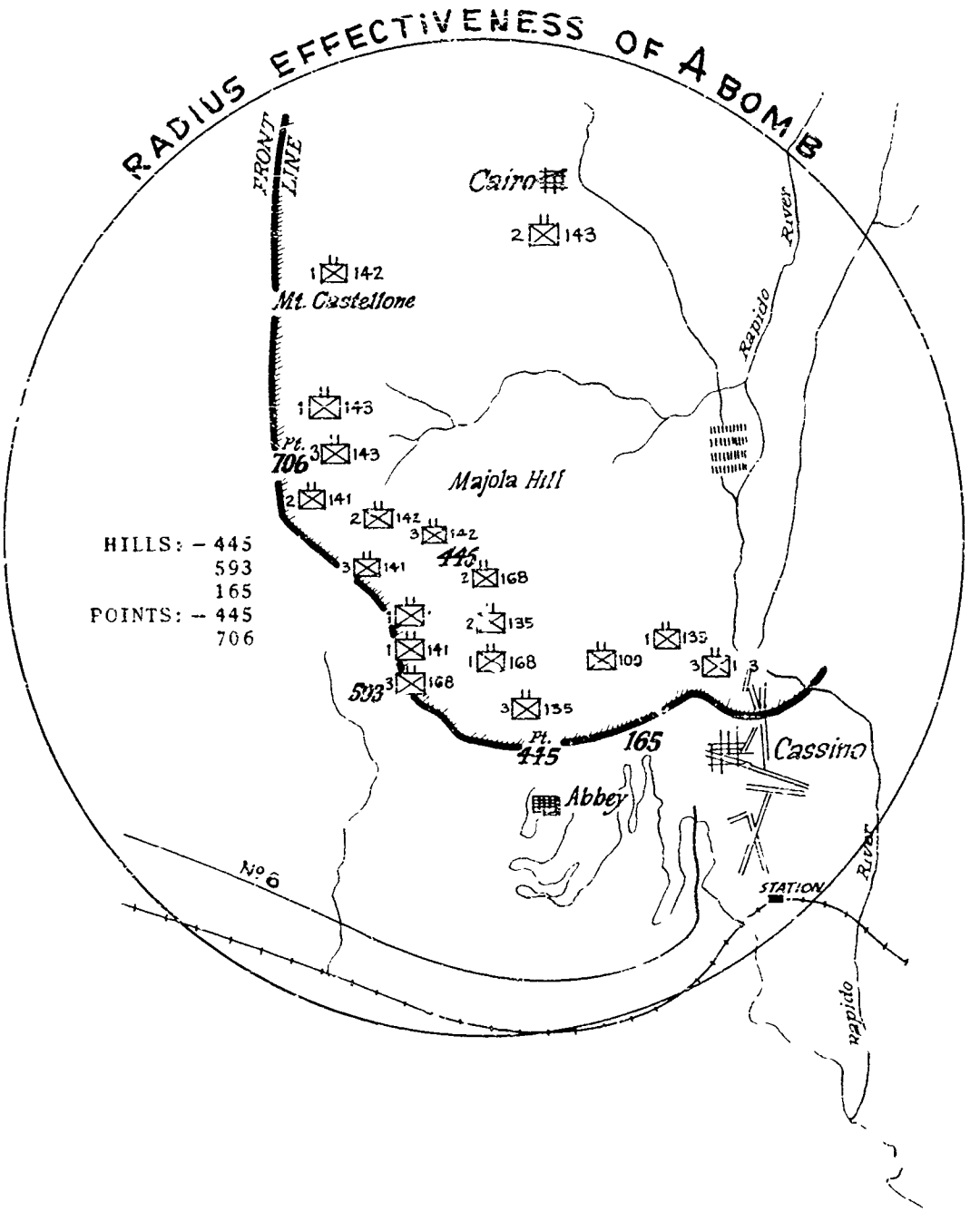
2nd Bn—Defensive position on Hill 706.

3rd Bn—Vicinity of Hill 593.

Regimental CP, ½ mile northeast of Hill 593.

Strength: At 1100 hours 11 February, the battalions were 60 percent understrength The 1st Bn had 10 officers and 66 enlisted men and the 3rd Bn, 12 officers and 94 enlisted men The operational strength report for the 36th Div shows for the 141st Regt:

	Officers	*Enlisted Men*
Present for duty 1 Feb 1944	175	2,631
Losses: Battle casualties 1–29 Feb	24	237



Map 13 —US Front at Cassino, 12 February 1944

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	Officers	Enlisted Men
Losses: non-battle casualties	19	304
Present for duty 29 Feb 1944	132	2,090

So that approximately 2,200 officers and men were present for duty 12 February.

142nd Regt

1st Bn—On Mount Castellone.

2nd Bn—On west slope of Hill 593.

3rd Bn—Prepared to repel a German counterattack on the 2nd Bn or to reinforce position held by 2nd Bn on Hill 468. In reserve in position supporting 2nd Bn at G 832226 the 2nd Chemical Bn, Co B was at G 857229 minus one platoon.

Strength: The strength of the battalion is as follows: 1st Bn 398 officers and men; 2nd Bn 100, and 3rd Bn 300 (on 15 February). The Division Operational strength report gives the following:

	Officers	Enlisted Men
Present for duty 1 Feb 1944	152	3,224
Losses: battle casualties 1–29 Feb	28	641
Losses: non-battle casualties 1–29 Feb	24	378
Present for duty 29 Feb 1944	100	2,205

So that the approximate average strength on 12 February was 2,200 men.

143rd Regt

1st Bn—On Hill 706 at point 836275.

2nd Bn—In reserve at point 888211 near Cairo.

3rd Bn—Defending Hill 706 at point 838242.

Strength: The regiment's effective fighting strength averaged 1,800 officers and men, as seen from the Divisional Operational strength report:

	Officers	Enlisted Men
Present for duty 1 Feb 1944	147	2,074
Losses: battle casualties 1–29 Feb	16	281
Losses: non-battle casualties	12	108
Present for duty 29 Feb 1944	119	1,685

Therefore in both the 34th and 36th Divs there were approximately 12,800 men (6,200 in the 36th Div and 6,600 in the 34th Div).

TABLE XII
HEADQUARTERS 168TH INFANTRY
UNITED STATES ARMY
APO 34
S-1 Effective Strength Report

No. 12 — From: 0001 hrs 12 Feb 1944; To: 2400 hrs 12 Feb 1944; Place. 848258, 1:25,000

SUB UNIT	OFF	WO	ENL MEN	TOTAL
1. *Effective Strength of Command:*				
Regtl Hq.	15	1		16
Headquarters Co	5	0	133	138
Service Co.	12	2	112	126
Antitank Co	4		104	108
Cannon Co	6		113	119
Medical Det	10		96	106
Hq Co 1st Bn	9		115	124
Company A	1		16	17
Company B	2		21	23
Company C	1		18	19
Company D	4		130	134
Hq Co 2nd Bn	9		112	121
Company E	5		65	70
Company F.	4		32	36
Company G	5		121	126
Company H	6		156	162
Hq Co 3rd Bn	11		121	132
Company I	4		75	79
Company K	2		60	62
Company L	4		52	56
Company M	5		144	149
	124	3	1,796	1,923
2. *Ration Strength.*				
168th Inf			2,923	
Division Hq			[illegible]	
34th Sig Co			13	
Arty Liaison			10	
109th Med Bn			16	
Miscellaneous			40	
			2,[illegible]7	

UNIT ON D/S TO	OFF	EM
3. *Detached Service Within Division:*		
Division Hq	1	0
34th QM Co	1	24

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US troops were not dug in as were the Germans as borne out by the following quotations:

"A strong criticism is, that in the usual American style, since the impetus was always forward, no artificial defenses had been erected. No wire, no mines, no obstacles and precious little improvement of individual shelters, has been accomplished during the twelve day occupancy of the position (1–12 Feb.). This, I believe, is common with U.S. troops and must be overcome. Defenses must start immediately with occupancy and improvement must continue until the position is abandoned." [16]

"The following are difficulties most usually encountered: The need for greater use of engineering and pioneering units to constantly improve front line positions, including not only weapons emplacements but even fighting holes for specific purposes such as sniping or observation. Dynamite, TNT, Beehive Mines, and similar explosive aids are not used sufficiently in our attempts to place fighting holes into extremely rocky soil. Battalions and Regiments should have their own personnel trained to employ such explosives to the greatest advantage in organizing a defensive line even when such organization is merely a short interlude prior to resuming the attack within a day or so." [17]

The weather from 5–14 February was reported to be rainy, cold, and on some days snow and visibility ranged from fair to poor. But on 12 February the weather was reported as "rain and sleet continued in the early morning but before noon the weather cleared. Through the operation (12–13 February) it remained cold." [18]

It would seem probable. therefore, that on the morning of 12 February an atomic bomb could have been dropped by the Germans wiping out many of the personnel in the 34th and 36th Divisions.

A bomb dropped south of Majola Hill (Map 13) by the Germans at a height of 600 yards would have killed 6,374 and hospitalized 1,334 of the 8,778 US soldiers in the area between Cairo and Cassino.

Reference to Table XIII indicates how these casualty figures were determined. The first column gives the battalion strength of the 18 battalions of US troops whose positions were known along the line on 12 February. The position of 4,122 soldiers were thus known. Moreover, the Effective Strength Report of the 168th Regt (see Table XII) indicates that in addition to these rifle companies, there would be within the radius of the bomb burst additional troops belonging to regimental and battalion headquarters, medical detachments, service companies, artillery liaison, et cetera, amounting to a total of 4,637 men for the two US divisions which are known to be within the area but occupying positions not definitely known. The artillery battalions themselves were across the Rapido River approximately 2 miles west of Cassino and therefore out of range of the bomb. An estimate of the number of men in each of the non-rifle companies is given in column 1 of Table XIII. Since all six regiments reported approximately the same total effective strength (i.e., 2,200 men), it is assumed that the distribution of men in other than rifle battalions are similar to the distribution of such men in the 168th Regt for which we have the detailed strength report of 12 February, shown in Table XII.

In the third column of Table XIII, the distance in yards that each rifle battalion is known to be from ground zero is read from Map 13. The 4,637 troops known to be present but whose actual positions cannot be determined (e.g., medical detachments, service companies, et cetera) are distributed proportionately in the neighborhood of each battalion.

Knowing, therefore, the distance that each group of men is from ground zero, the percentage of deaths (u) and hospitalizations (w) can be read from Figure 25 and the actual numerical values computed from Table XIII

[16] Col G. E. Lynch, Col 142nd Inf, Commanding. Quoted from *Operations in Italy, 142nd Inf Regt, 36th Inf Div*, February 1944.

[17] Lt Col John C L. Adams, Commanding 141st Inf. Quoted from *Operations in Italy, 141st Inf Regt, 36th Div*, February 1944

[18] *Operations in Italy, 142nd Inf Regt, 36th Inf Div*, February 1944

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TABLE XIII

COMPUTATION OF CASUALTIES—CASSINO

UNIT	1 NUMERICAL STRENGTH	2 DISTANCE FROM GROUND ZERO	3 NUMERICAL STRENGTH EXPRESSED	4 DEATHS, U	5 HOSP. AND W	6 DEATHS, D	7 HOSP. NO.
168th:		yd		%	%		
1st Bn	193	1, 260	411	100		411	
2nd Bn	394	445	839	100		839	
3rd Bn	346	1, 820	737	96	4	707	30
133rd:							
1st Bn	200	2, 780	426	34. 5	52. 5	147	223
2nd Bn (100th)	200	1, 840	426	96	4	409	17
3rd Bn	200	2, 810	426	26	58	111	247
135th:							
1st Bn	200	1, 070	426	100		426	
2nd Bn	200	900	426	100		426	
3rd Bn	200	1, 810	426	96. 5	3. 5	411	15
141st:							
1st Bn	76	1, 330	162	100		162	
2nd Bn	100	1, 790	213	97. 5	2. 5	208	5
3rd Bn	106	1, 210	226	100		226	
142nd:							
1st Bn	398	3, 020	848	20	30	170	254
2nd Bn	100	1, 040	213	100		213	
3rd Bn	309	445	658	100		658	
143rd:							
1st Bn	300	1, 980	639	93. 5	6. 5	597	42
2nd Bn	300	3, 020	639	20	30	128	191
3rd Bn	300	3, 040	639	19. 5	48. 5	125	310
Total						6, 374	1, 334

	Numerical Strength
Hqs Co:	
168	138
133	138
135	138
141	138
142	138
143	138
Service Co.	
168	126
133	126
135	126
141	126
142	126
143	126
Med Det:	
168	106
133	106
135	106
141	106
142	106
143	106
Hq	
168	15
1st Bn	124
2nd Bn	121
3rd Bn	132
Hq:	
133	15
1st Bn	125
2nd Bn	125
3rd Bn	125

	Numerical Strength
Hq:	
135	15
1st Bn	125
2nd Bn	125
3rd Bn	125
Hq:	
141	15
1st Bn	125
2nd Bn	125
3rd Bn	125
Hq:	
142	15
1st Bn	125
2nd Bn	125
3rd Bn	125
Hq:	
143	15
1st Bn	125
2nd Bn	125
3rd Bn	125
Arty Liaison	15
168	10
133	10
135	10
141	10
142	10
143	10
Total	8, 759
Total whose position is known	4, 122

[redacted]

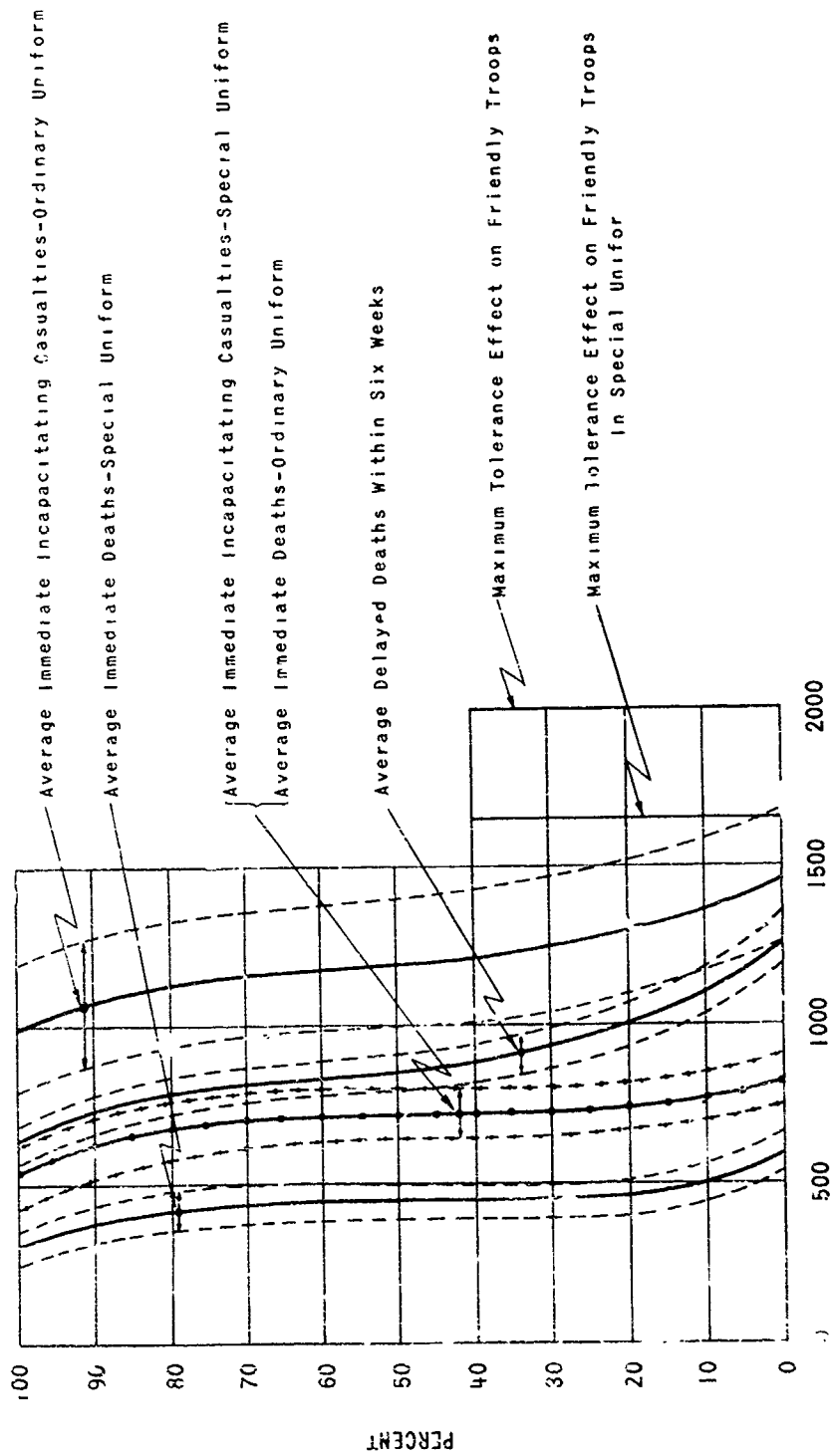


Figure 25.—Casualties Among Troops in the Open Exposed to a 20 KT Atomic Weapon Exploded in the Air at a Height of 600 Yards, on a Clear Day

(Note: Ordinary uniforms predominant cause of casualties is thermal radiation; in special uniforms it is gamma radiation; delayed deaths are principally those from gamma radiation.)

But even though an atomic bomb would have killed or hospitalized all but 1,170 of the 8,759 US troops present in the Cassino area, it would not be obviously advantageous for the Germans to have used the bomb then because they were not in a position to exploit their resulting numerical superiority. They were well dug in, in defensive positions, and apparently could hold their position without resorting to the use of an atomic bomb.

THE NEW ZEALAND CORPS AT CASSINO AND RESULTS OF THE BOMBING OF CASSINO

The New Zealand Corps was formed specifically for the Cassino battle from the 2nd New Zealand Division, the 4th Indian Division, and the British 78th Infantry Division.

All but one battalion of the US infantry on the front line were relieved by the end of February by the New Zealand Corps.

THE 15 FEBRUARY BOMBING OF THE ABBEY

On 15 February the abbey was destroyed by 576 tons of bombs but its usefulness to the enemy was only impaired. After each wave of bombers passed over heavy artillery fired on the target. II Corps Artillery fired a serenade of 266 rounds at 1030. Ten 240mm howitzers and twenty-four 8-inch howitzers fired 5 rounds each; twelve 4.5-inch guns and twenty-four 155-mm guns fired 4 rounds each.

When the bombing was over, enemy troops occupied Hill 593 and so regained without effort, a key position that had been the scene of much bitter fighting by Allied units. On 16 February 24 tons of bombs were dropped on enemy positions in the same area.

Gains were small and lines changed but little from 12 February to the end of February. From the end of February until 15 March there was a lull in the fighting while both sides regrouped.

THE 15 MARCH BOMBING

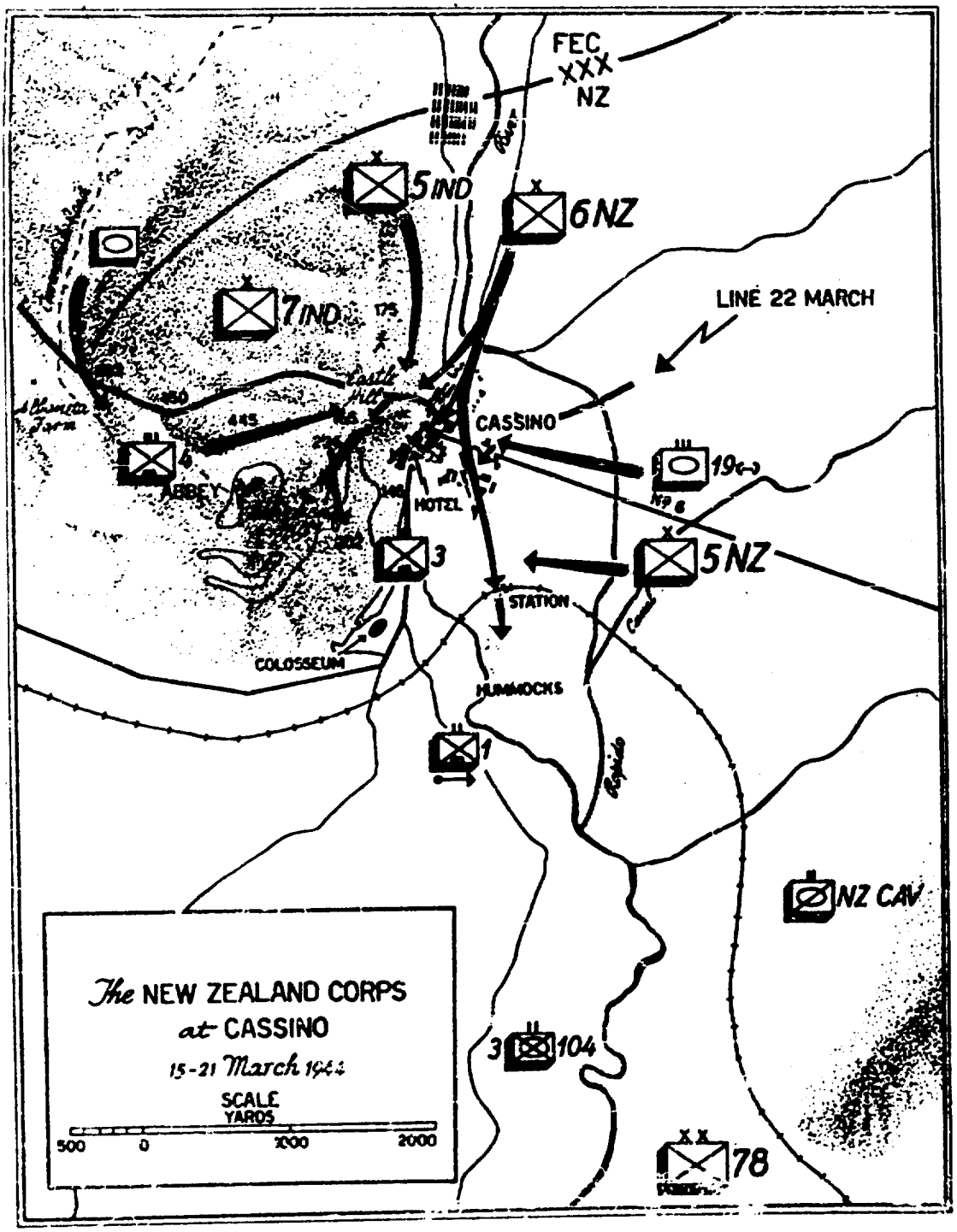
On 15 March, 1,184 tons of bombs were dropped in and around Cassino from 0830–1200; from 1300–1500, 18 tons were dropped on the Cassino railroad station; from 1345–1630, the Colosseum area south of Cassino was hit with 44 tons; and between 1500 and 1700, the forward slopes of Monastery Hill were hit with 10 tons. Another 34 tons were dropped on miscellaneous targets.

From 1200–2000, the terrific artillery concentration by 890 pieces took place, 195,969 rounds being fired.

But the tremendous weight of bombs and artillery fire on 15 March did not destroy the enemy's defenses in Cassino and on Monastery Hill. Protected by cellars, steel and concrete pillboxes, caves, and tunnels, the German troops suffered comparatively few casualties (see *Supplementary Miscellaneous Data* immediately following).

After the terrific air and artillery blows, the New Zealand Corps made the first effort on the ground to capture Cassino. At the end of 3 days, most of the ridge from Castle Hill to Hangman's Hill was in Allied possession, two-thirds of Cassino had been captured and the line extended south beyond the railroad station. The key to the situation was still Monastery Hill. The 1/9 Gurkha Rifles on Hangman's Hill were less than 500 yards from the abbey and less than 300 yards separated the 24th and 25th New Zealand Battalions from the southern edges of Cassino. Short as these distances were their forces were unable to break through.

The New Zealand Corps had 24 infantry battalions; the enemy had 14. There were about 16 enemy tanks in Cassino at any one time and possibly 90 were available in the Liri Valley; Allied armor included 579 tanks, 59 armored cars and 128 self-propelled guns. In spite of this impressive superiority in air, artillery, infantry, and armor, gains by the Allies were these: a few more blocks of courtyards and walls, Castle Hill and a precarious hold on the railroad station (Map 14). Our armor could not be employed effectively because of cratered roads, soggy ground, and debris. Tanks could not get through the rubble and water-filled craters produced by the bombings. Engineers could not clear the



Map 14.—The New Zealand Corps at Cassino, 15-21 March 1944

way until local resistance had been eliminated, but the infantry needed tanks to clear the strongpoints holding up the engineers. Artillery fire could not destroy the well-prepared pillboxes, so strongly built that some withstood even direct bomb hits. The proximity of our own troops to the enemy also hampered the artillery.

The entire Fifth Army attack on the southern front had been disappointing in its results. By the end of March, the German line was essentially the same as on 12 February when the II Corps was exhausted and had relinquished the battle to the New Zealand Corps.

PROBABLE INEFFECTIVENESS OF AN ATOMIC BOMB USED AGAINST THE GERMANS

It does not seem probable that an air burst atomic bomb would have been any more effective in routing the Germans than the 1,290 tons of bombs dropped on 15 March.

The Germans, in contrast to the Allies, were entrenched in extremely well-fortified positions, cellars, steel and concrete pillboxes, caves, and tunnels that in many cases were so strongly built that they could withstand even direct bomb hits (see following section, *Supplementary Miscellaneous Data*).

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SUPPLEMENTARY MISCELLANEOUS DATA
MEDITERRANEAN ALLIED AIR FORCES
THE BOMBARDMENT OF CASSINO
15 March 1944

SITUATION

In December 1943, the front in Italy reached a deadlock which persisted into March despite all Allied efforts. Entrenched across the narrowest and most mountainous part of the Italian peninsula, the German Army established an extremely strong defensive position, the so-called "Gustav Line," which Hitler himself ordered them to hold at all costs. The linchpin of the Gustav Line was the little town of Cassino, famed for its Benedictine Monastery and so situated that it commanded the best route to Rome, Highway 6. Some 5 miles back of Cassino, the Germans established another strong position known as the "Adolf Hitler Line" to which they were apparently ready to withdraw when forced from Cassino.

The Cassino position offered the Germans unique defensive possibilities. The little Rapido River flowing in front of it made a natural barrier considerably enhanced by the abnormally bad weather in early 1944. The town itself was built entirely of stone, some of it dating back to Roman times and all ideally arranged for fortification purposes. Under the town was at least one ancient tunnel, forming an impregnable air raid shelter and communications line. Sheer behind the town lay the steep slope of 1,500-ft Monte Cassino and behind it the snowy, 5,400-ft peak of Mount Cairo. At the foot of this formidable bastion is the broad Liri Valley floor leading to Rome and appearing to offer ample room for tanks to maneuver. Actually, however, the valley is so low and swampy that tanks must follow the roads. And the only real road, Highway 6, passed through Cassino and along the flank of Monte Cassino, directly under the German guns.

The troops holding this key position were Germany's best, some 4,000 to 5,000 tough, young Nazis of the 1st Parachute Division. Their high morale and fighting calibre are indicated by a captured Order of the Day issued by their Commander, Col Schulz, on 15 February. Excerpt:

> [The Worldpress, the House of Commons, the House of Lords, the Conferences the world over—all are shouting their heads off about you. The Holy Father has intervened on account of the famous Monastery of Monte Cassino. Our front has become the affair of the utmost political importance.
>
> I realize what indescribable hardships, through the weather and lack of warm meals alone, you have had to endure: I am aware when the Americans were weakened, English and Indian troops were then thrown in the line. But I am convinced that you, the finest troops in the world, will be equal to the task.

INTENTION

It was decided to attempt to smash the Germans from Cassino by an all-out aerial and artillery bombardment followed immediately by an attack by infantry supported by tanks. In its broad outlines, the plan was simple. When weather promised both clear skies and dry footing, the Allied troops would pull back about 1,000 yards from Cassino before dawn. every available bomber would attack the town in the morning, and at noon, under the cover of an intense rolling barrage, the troops would swarm back into what was left of Cassino in hopes of taking the entire town and its abbey Meanwhile, in the afternoon, the bombers and artillery would range ahead down the valley. Combat Command B was ready to exploit the capture of Cassino with a large-scale attack which it was hoped would breach the Gustav Line completely and carry through to the Adolf Hitler Line 5 miles nearer Rome.

PLANS

The air plan specified morning attacks on Cassino at 10 or 15 minute intervals by 11 heavy groups of the Mediterranean Allied

Strategic Air Force and 5 medium groups of the Mediterranean Allied Tactical Air Force. The object of this attack was "to accomplish reduction of Cassino Town." For flexibility's sake, two alternative time schedules were laid down—one to commence at 0730 and last until 1100, the other to commence at 0830 and last until 1200. The second schedule was followed. Only 1,000-lb instantaneous HE bombs were loaded for this part of the attack. For the afternoon, however, B-25 units were to shift to fragmentation bombs.

The plan for the afternoon attack, with which this report is less concerned since weather and the course of the battle caused much of it to be called off, specified second sorties by both heavy and medium groups on a variety of towns and gun positions behind Cassino. After 1205 *no* bombing of Cassino was scheduled except for fighter bombers on call from the advancing Allied troops.

AIR OPERATION

In its final form the attack was scheduled to begin at 0830 hours and continue through 1200 hours with a 10-minute period allowed for the bombing by each of the participating groups. It was directed that no bombing of the town proper was to be done after 1205 hours. One-thousand-lb GP bombs, fuzed .1 second nose and .025 sec tail were employed by all bombers. The altitudes specified for the heavy bombers were 15,000 to 16,000 ft and for the medium bombers, 7,000 to 9,000 ft, consistent with the normal operating altitudes for these aircraft. It was anticipated that heavy flak would be encountered from the more than 80 dual-purpose 88mm and 137mm guns in the area surrounding Cassino. Air Intelligence also indicated that 60 to 80 enemy fighters were within operational range and might oppose this attack. Neither opposition, however, materialized. The assigned target area, encompassed within a 1,250-ft radius of the center of the town, was divided among the heavy and medium groups; the "A" (or northern half) being designated principally for mediums and the "B" (southern half) for the heavies. These two areas were attacked alternately, thus allowing for maneuvering of the attacking groups between the initial point and the target.

At noon, a P-38 reconnaissance plane flew in low over the town. The pictures it took confirmed the impression of ground observers 2 miles away—that Cassino was as flat as a stone city can be. There were peaks of broken buildings still standing, but the overall landscape was only a misshapen pile of rubble.

Statements of prisoners of war throw additional light on the bombing results. In reading them it is important to bear two things in mind: only a handful of Germans were captured who were actually *in* the town during the bombardment; and these men were the arch-type of Nazi, arrogant, very security-minded veterans who obviously lied on some occasions and generally exhibited bravado about the bombing. The following facts appear, however, to be pretty well authenticated.

About 950 Germans of the 1st Parachute Division were in or near the town on the morning of the 15th; the 2nd Battalion, consisting of 5 to 8 companies, in the northern end of the town, the 1st Battalion between Point 193 and the abbey; and the 3rd Battalion in the southern end of the town. Only the 2nd Battalion caught the full weight of the bombardment and it appears to have suffered very heavily. One prisoner of war said he was the only survivor of his group of 15 to 20 men. Another estimated that of an initial strength of 60 men in 5 companies not more than 6 survived. The other companies appeared to have fared better. When the bombardment began, they apparently pulled back into deep caves in Monte Cassino, or into the tunnels, and sat out the bombing in considerable discomfort but reasonable safety. Some were buried in the rubble and dug their way out just in time to be captured. There were 17 prisoners of war taken the first day and 34 the second. By March 24, prisoners of war totaled 278, but most of these were from the 2nd Battalion of the 115 Panzer Grenadier Division which came up from behind Monte Cassino to reinforce the battered battalion of the Parachute Division in the town after the bombardment.

Prisoner of war statements were summarized as follows by interrogating officers:

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"Owing to the fact that Cassino had previous to 15 March been subjected to intermittent but heavy artillery fire, few buildings had been left in condition to afford adequate cover for either men or material. The main type of cover available consisted either of basements of already partially destroyed buildings, or of bell-shaped pillboxes. There are apparently various types of these, but all are made of steel 2½ to 4 inches thick. They are constructed to accommodate 2 men comfortably, but owing to the lack of other suitable protection, as many as 6 men managed to squeeze into one during the emergency. These pillboxes are normally sunk into the ground deep enough to allow only the dome-shaped top to protrude. They can be lifted by a 2½ ton lorry . . .

"Bombs falling three to four yards from a pillbox lifted it out of its position without seriously harming the men inside. Men sheltering in basements and cellars were frequently buried beneath the falling masonry . . . Ammunition and weapons, which had been stacked in cellars or in damaged buildings, were largely destroyed beyond recognition and it was possible to salvage but little. Many men left their weapons unattended in their haste to seek refuge and were unable to retrieve them afterwards.

"Apart from an initial panic, the morale of the soldiers seemed to have maintained the normal high level of paratroops. Fighting efficiency probably suffered much more severely owing to a natural instinct of self-preservation and the huge clouds of smoke and dust caused . . .

"All prisoners of war, particularly those who were in Cassino proper, were unanimous in stating that the defense system was completely broken down and that it became impossible to pass messages as all telephone lines were destroyed. In addition, the general chaos and bad visibility prevented the local situation from being accurately assessed or reported. One prisoner of war from 2 Coy states that 2 runners were killed by splinters before they could reach Coy Headquarters."

GROUND OPERATIONS

Immediately following the air bombardment, Allied artillery laid a very heavy barrage upon the town. As it crept forward, the New Zealand infantry and tanks attacked from the north. It is not the province of this report to analyze the ground operations.

First difficulty reported by the advancing soldiers was in getting through the damage done by the bombs and artillery. Tanks were halted completely by enormous craters in all the roads into the town and could not proceed until engineers, working under fire, had built bridges as long as 70 feet across them. In the town the infantry found the streets so full of rubble that one New Zealand brigadier estimated that under ideal conditions (i.e., no enemy fire) it would have taken bulldozers 48 hours to clear a single path through Cassino. There seems to be some reason to believe that these delays gave the Germans just time enough to crawl out of their holes in the rock and take up strong sniping and machine-gun positions amid the ruins.

In any event, the New Zealanders and supporting Indians found themselves in a very difficult fight. Even so, they surged through three-quarters of the town and up the slopes of Monte Cassino to the highest promontory below the abbey itself—Point 435. But here and on Points 202 and 165, they were cut off, on the night of 18 March, by a German infiltration of several companies into the town. There seems good reason to suspect that the tunnels below Cassino, having saved the paratroopers during the bombing, now enabled reinforcements to appear in the middle of the Allied positions. Extraordinarily fierce fighting followed with many points changing hands several times and with heavy casualties on both sides. Supplied by containers dropped by dive-bombers, the troops on 435 and 202 held out for several days. Then they withdrew. By 26 March it became apparent that a decisive breakthrough could not be achieved. The Germans held most of Monte Cassino with the exception of Point 193. The Allied troops retained, however, possession of nine-tenths of Cassino and a very substantial bridgehead

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across the Rapido, advances which previously they had been unable to make. There appeared to be substantial agreement among the ground commanders that this limited success could not have been achieved without the preliminary aerial bombardment.

AIR LESSONS LEARNED

Invaluable experience in the use of close air support was provided by this operation. No attempt is made here to interpret the ground phases of the attack. The air phases did, however, afford a basis for planning future use of intensive support.

The cost, in bombing effort, of destroying an enemy force that is established in well-prepared positions is high. A bomb-density of approximately 5.5 tons-per-acre was achieved in the town of Cassino. There were 6.2 tons expended per casualty effected within the town. As stated in the body of this report, the enemy troops had access to caves, deep dugouts, and tunnels which protected them not only against fragments but also against blast effects.

Where the bombardment must be confined to a small area, medium bombers and fighter-bombers are prescribed since their lower altitudes of operation make possible a high degree of accuracy, even under conditions of ground haze, bomb-smoke, and dust. If, because of their bomb loads, heavy bombers are desirable, they should be used only where absence of flak and fighter opposition will allow them to bomb from altitudes below 10,000 feet. The heavy bombers are best suited to long-range attacks against strategic targets and the techniques and experience of their crews are normally unsuited to close air support operations.

Where a large-scale effort is to be used against a small area, some positive means of target or aiming-point identification is necessary. After the first wave of the attack the target is completely obscured by dust and smoke and scattering of the bombs of succeeding waves is unavoidable.

The 10- and 15-minute interval between the bombing attacks was unnecessary and the same weight of attack could have been concentrated in a much shorter period.

In the absence of any real opposition either from enemy fighters or flak, it would have been better to bomb along the line of the front instead of having the axis of attack perpendicular to it. This would probably have prevented shorts from falling upon Allied positions and might also have resulted in fewer craters on the approaches to the town from the Allied side.

The fact that Germans, not actually in Cassino, suffered few casualties indicates that it might have been better to disperse some of the attacks on the fringes of the town and use fragmentation and antipersonnel bombs in this more open terrain.

CONCLUSIONS

The air objective—to destroy Cassino—was achieved.

There comes a point, however, in the destruction of any stone town when additional damage merely makes the fortifications stronger by piling rubble about them. The Soviets learned this to their advantage at Stalingrad. Cassino provided unwelcome confirmation.

Any such utter destruction as was visited upon Cassino cannot fail to produce a complete road block, giving an advantage to the defender and inevitably delaying the offensive. This may indicate that such all-out air attacks upon fortified towns are better suited for defense, as at Battipaglia during the Salerno battle, than for the opening blow of an Allied attack, as at Cassino.

The limited success which was achieved would have been impossible without the aerial bombardment.

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Specific Restrictions Governing Reference Not Required
Use Military Classification Standards

ALLIED FORCE HEADQUARTERS
APO 512

4 June 1944

TRAINING MEMORANDUM
NUMBER 5

LESSONS FROM THE CASSINO OPERATION
(15 – 25 MARCH 1944)

I. GENERAL

No new lessons were learned from the air and ground action at CASSINO. Established principles were confirmed. Certain methods of improvement in operational technique have been advanced in the reports of the air and ground commanders

II. GENERAL LESSONS APPLICABLE TO COMBINED AIR AND GROUND OPERATIONS, REPORTED BY BOTH AIR AND GROUND COMMANDERS

Reported by Air Commander

1. The bombing of an enemy strong point such as Cassino must be followed by a determined and vigorous ground attack which must be initiated in the shortest possible time after the last bomb has been dropped.

2. Employed in close support of a ground operation, air bombardment cannot be expected to obliterate strong defences and determined resistance. This is especially true in the case of a fortified town such as Cassino.

3. Heavy bombing of a strongly defended town will produce craters and masses of rubble from demolished buildings which become serious obstacles in the advance of attacking infantry and armored vehicles. These obstacles will also provide the enemy with advantageous firing points and positions for defense.

4. Provisions must be made for bomb line markers which can be clearly identified from the air at bombing altitudes.

5. The capabilities and limitations of each arm must be mutually understood and appreciated. The closest cooperation must be achieved between the commanders and staffs of both arms.

Reported by Ground Commander

1. The follow up of the infantry must be immediate and aggressive, employing the maximum infantry strength available. The maximum amount of infantry was not employed in this attack, nor was the attack aggressively pushed. Too great reliance was placed on the ability of the bombing to do the task alone.

2. The town of Cassino was not only fortified but use was made of cellars and tunnels. Despite the tremendous air effort, our infantry were met by a determined enemy in well fortified positions. It follows therefore that no aerial bombardment alone can clear a fortified area of infantry who are well dug in.

3. The heavy bombing hindered our advance by cratering and blocking of routes with debris. Due to cratering few tanks could enter the town. The tonnage of bombs to be dropped must be carefully considered in the ground plan of action, as debris and cratering hinders the use of armor.

4. Every possible means must be used to insure accurate identification of the targets by the pilots.

5. Not specifically stated in the ground commander's report, but implied from study of the report as a whole.

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Specific authorization required for release to military classification safeguards

III. LESSONS APPLICABLE TO THE AIR OPERATIONS

1. Unless otherwise indicated, the following points are extracted from the report of the air commander.

2. In the Cassino operation both the Tactical and the Strategic Air Forces were employed. The Tactical Air Force gave better performance and results, largely because close support is a normal operation for this type of air force. Conversely, close support missions are rare operations for the Strategic Air Force, which has had little training and experience in such operations.

3. In general, heavy bombers should not be used in close support operations when there is present an adequate Tactical Air Force.

4. When operations require the use of the heavy bombers in close support of ground operations, the following recommendations are advanced by the air commander:

a. When practicable, bomb leaders and leading navigators should make a previous flight over the target area.

b. Bombing altitudes should be specified. The heavy bombers showed a tendency to bomb from too high an altitude.

c. Angles of approach should be specified, especially when ground troops are close to the target area.

d. Intervals between bomber groups, especially when the wind is sufficiently strong to clear the smoke from the targets, should be decreased. The whole bombing operation should be concentrated in the briefest possible time.

e. A member of the Strategic Air Force Commander's staff should be present in position to observe the bombing action of his units, and should have radio communication with his units in the air.

5. A percentage of bombs should be fuzed for delay action to reach cellars and penetrate heavy covered emplacements (*reported by ground commander only*).

6. In a large scale bombardment in which aircraft approach the target area from widely scattered points, an unmistakable artificial landmark such as smoke for the orientation of navigators would assist the entire air effort (*reported by the ground commander only*).

7. Alternate targets should be designated in case some flights of aircraft are late at the end of the schedule (*reported by the ground commander only*).

8. Air re-supply of ground units with A-36 aircraft using either parabundles or belly tanks proved to be practicable. Targets for drops must be clearly marked and pilots must be carefully briefed and provided with accurate air photographs and large scale maps (*reported by the ground commander only*).

9. Despite its casualty effect and morale effect on enemy personnel, air bombardment by heavy bombers is not sufficiently accurate for general use in the tactical area of land battle (*reported by commander, Allied Armies in Italy*).

IV. LESSONS APPLICABLE TO THE GROUND OPERATIONS

1. Unless otherwise indicated, the following points are extracted from the report of the ground commander.

2. The infantry assault following the air bombardment must be immediate and aggressive and in maximum available strength. The maximum amount of infantry was not employed in this attack, nor was the attack aggressively pushed. Too much reliance was placed on the ability of bombardment to eliminate the opposition.

3. The initial assault waves must follow quickly the artillery barrage. They should not stop to mop up isolated strong points and small centers of resistance. Such centers of resistance should be left to clearing or mopping up parties following the initial assault.

4. Continued emphasis must be placed on the technique of street fighting in the training of infantry. No new lessons in this subject were learned, but its importance was clearly apparent.

5. Only a few tanks could enter the town in support of the infantry because of the craters and rubble. Those that did rendered valuable support.

6. A few lighter self-propelled guns might have rendered limited assistance in some area.

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7. In a heavily defended town, artillery is unable to give close support fire.

8. Since close artillery support is not possible in attacking a heavily defended town, engineers, mortar crews, and tank destroyer crews must follow closely the assault.

9. The enemy could not be denied dominant observation of our movements in the town. This factor must be considered by ground commanders in any similar situations comparable to that at Cassino.

V. Extracts from a Report by the Director of Military Training, the War Office

The following extracts are taken from a report compiled by the Director of Military Training, the War Office, from preliminary reports received by him.

They have not been approved by the Commanders responsible for the operation, and should therefore be accepted with reserve.

"1. Planning

a. It has been suggested that, in addition to other means, the AA brigadiers whose guns cover the airfields from which the bombers are operating should be informed of the detailed Army plan and should be used as senior Army/Air Liaison officers charged with ensuring that the briefing of the pilots on their airfields is adequate.

b. The morale effect of a continuous bombardment, either aerial or artillery is much greater than that of intermittent bombardment of the same total weight.

c. The Strategic bombers will probably be operating from a height of 20,000 feet and until they have much greater experience of the technique involved in close support bombing, they are unlikely to be as accurate as the Tactical Air Force medium bombers. This will mean that a fair percentage of the bombing effort will fall outside the target area. Any planning, therefore, which has been prepared on a timed basis and which assumes that in an agreed time a certain weight of bombs must inevitably fall in a given area, is likely to go astray. It must be left to the military commander who is in charge of the operation, to ask for a continuance of the bombing until saturation has been achieved, and not until he is satisfied on this point should the bombing effort stop and the ground forces begin their attack.

d. Much of the responsibility for the inaccuracies mentioned in the paragraph above, may be attributed to the Army. It is their duty to help the bombers to find the target, and some or all of the following aids can be used:

(1) Very large artificial marks (such as bulldozed or white arrows) as a fixing point some way behind our own lines.

(2) Further signs (colored flares, ground signs, etc.) close behind our forward positions.

(3) Flashing colored searchlights at the aircraft from pre-arranged places.

(4) Giving Wing Leaders of the bombing formation a preliminary fly round in a Piper Cub or Auster aircraft

(5) Direct wireless communication ground/air to enable briefing in the air to take place.

"2. Employment of tanks

Tanks should be retained as a reserve for the quick follow up once the way has been cleared by the infantry and engineers.

"3. Employment of infantry

In attacking towns it will usually be necessary to divide the town into sectors, detailing appropriate bodies of troops to deal with each sector. Infantry reserves should also be well forward, and it is clear that a delay of even an hour in committing the full weight of the infantry attack may well prejudice the success of the whole operation. In this connection reserves may have to be located in terms of time rather than distance.

"4. Employment of engineers

Until the engineers have been able to reconnoitre the damage done by the bombardment, and until they can bring forward their mechanised equipment for clearing a passage, tanks and M.T. of the infantry will be immobilized. It is essential, therefore, that engineer officers should accompany the first infantry waves, and the engineer parks should be sited well forward.

"5. Conclusions

CASSINO is not an indictment of the value of heavy bombers in close support of the Army. Their ability to land a knockout blow, without warning is still an advantage which no other form of attack enjoys, but it must be realized that there are limiting and controlling factors for this as with all other types of fire support."

By command of General WILSON

J. A. H. GAMMELL,
Lieutenant General,
Chief of Staff

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HEADQUARTERS

MEDITERRANEAN ALLIED TACTICAL AIR FORCE

Reference: 11 July 1944
TAF/69/AIR

ATTACK ON CASSINO, ITALY, 15 MARCH 1944

Appendices:

Appendix 'A'—Detailed plan for Air Bombardment.

Appendix 'B'—Plan for Infantry and Tank Attack.

Appendix 'C'—Timing and Results of Air Attack.

Appendix 'D'—Report on Attack by HQ, 5th Army.

Appendix 'E'—Report by M.A.T.A.F. Ordnance Officers on Visit to CASSINO.

INTRODUCTION

1. The attack on the town of CASSINO on the 15th of March 1944, is of particular interest, as owing to the failure of the many previous attempts to capture the town by the more normal methods, in this operation an attempt was made to overcome the fierce enemy opposition by a preliminary, intense and concentrated air and artillery bombardment. It was hoped by this means that the defenders would be so demoralized and dazed that our ground forces could occupy the town with little difficulty.

TACTICAL IMPORTANCE OF CASSINO

2. CASSINO, through which passes Highway 6, one of the main highways to ROME, lies at the junction of the RAPIDO and LIRI Valleys. The town itself is situated on the lower slopes of a high feature known as MONTE CASSINO, which dominates both valleys, Highway 6 and those parts of the RAPIDO River, which can be bridged at this time of the year.

3. It was essential to make use of Highway 6 for an advance up the LIRI Valley, which was the only feasible axis of advance for the capture of ROME by troops on this front. The capture of CASSINO town and the MONTE CASSINO feature, was, therefore, of the utmost importance.

4. German forces were strongly established both in parts of CASSINO town and on MONTE CASSINO, and on the intervening slopes. They had taken full advantage of the sturdy concrete and stone buildings in the town, and cellars reinforced with heavy timber had been transformed into strong points. Furthermore, the entrances to caves in and about the town afforded good bomb-proof shelters, gun positions and observation points. At the time of the operation, we held a footing in the Southern part of the town.

5. Several attempts had been made to capture CASSINO. First a frontal attack was carried out simultaneously with the ANZIO landing. In this attack our troops succeeded in crossing the RAPIDO River just south of the town, but were forced to withdraw owing to heavy counterattacks. Later, several attempts were made to outflank the town from the NORTH and to capture MONTE CASSINO, but these also failed, even after the Abbey, on its summit, had been reduced by heavy bombing.

6. It is of interest to note that both the German and Italian high commands fully appreciated the importance and strength of this position, forming as it did a natural bastion in the defense of ROME. In fact, the situation that now presented itself had frequently formed the basis of Staff College studies on defense in times of peace.

GENERAL PLAN FOR THE OPERATION

7. The general plan of the operation was divided into the following three stages:

(i) The capture of CASSINO town.

(ii) The seizing of MONTE CASSINO by simultaneous attacks from the east and west.

(iii) The establishing of a limited bridgehead across the RAPIDO River in the area SAN ANGELO to CASSINO, where sufficient tank and artillery forces could be concen-

trated for a final break through into the LIRI Valley.

8. The Army appreciated from past experience that, owing to the strong natural and artificial defences, ground forces alone could not capture the town without suffering heavy casualties. It was therefore agreed that an attempt should be made to surprise the enemy by an intense and concentrated air bombardment, followed by a heavy artillery concentration. It was hoped by this means to so stupify and demoralize the defenders that the ground forces could attain their objective with the minimum of loss

9. The governing factor in deciding "D" Day for this operation was, of course, the weather, both from the point of view of being able to carry out the air bombardment and also the ability to operate tanks over this somewhat naturally marshy ground. At this time of the year the weather can be extremely variable and as it turned out it was some three weeks after the plan was made before conditions were suitable. Further, the decision to lay the operation on had to be taken some hours before "H" hour to enable our forces occupying their part of the town to be withdrawn in safety before the bombardment commenced.

DETAILED PLAN

10. *Phase "A"—Air Bombardment*

(i) The plan demanded that a minimum of 750 tons of bombs should be dropped in the town area in the shortest possible time. Having regard to the nature of the defenses it was decided that bombs of 1,000 pounds weight and over be used and that fusings should permit penetration of buildings down to basement depth.

(ii) In order to provide this weight of attack it was decided to utilize the Mediterranean Allied Strategic Air Force, in addition to the five Groups of Medium Bombers available to the Tactical Air Force. Formations were scheduled to attack in waves every 15 minutes from 0830 to 1200 hours. The detailed programme of attacks is attached at Appendix "A".

11. *Phase "B"—Artillery Bombardment*

The air bombardment was to be followed by a heavy artillery bombardment on enemy strong points, heavy gun positions and observation points lasting 40 minutes.

12. *Phase "C"—Infantry and Tank Attack*

The advance of the infantry into CASSINO was to commence at the conclusion of the main artillery bombardment and was to be covered by a creeping artillery barrage moving through the town 100–200 yards ahead of them. Fighter bombers of XII Tactical Air Command were to be available to assist the assault by attacking pre-selected targets under the direction of a forward fighter controller. Details of the plan for the infantry and tank attack are attached at Appendix "B".

EXECUTION AND RESULTS

13. *Phase "A"—Air Bombardment*

(i) Between 1830 and 1200 hours on 15th March, the CASSINO area was bombed by 72 B–25's, 101 B–26's, 262 B–17's and B–24's, totalling 435 aircraft. In all, 2,214 one thousand pound bombs were dropped, making a total weight of 988 tons. Of these, it is estimated that some 300 tons fell in the actual town itself, the remainder falling on the slopes of MONTE CASSINO and in the nearby vicinity.

(ii) The timing and full results are shown in Appendix "C". From this it will be seen that whereas the attacks by the Medium Bombers were generally punctual and the bombing concentrated and accurate, Heavy Bombers were frequently at fault in all these respects. Consequently, not only did the target not receive the full weight of bombs intended, but there were frequent long pauses between attacks.

(iii) Certain of the Heavy Bombers were unable to identify the target, 23 returning to base with their bombs and two jettisoning theirs into the sea. Due to rack failure on the leading aircraft of one formation, 40 bombs were dropped within our lines, resulting in a number of military and civilian casualties.

(iv) Little flak was experienced and no enemy aircraft were encountered. We suffered no losses.

14. *Phase "B"—Artillery Bombardment*

(i) *Operations 15th March*

At 1200 hours the artillery bombardment opened and the leading battalion began to cross the 1,000 yards which separated

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them from the town. By 1300 hours they had secured a foothold in the town and some of our old positions on the southern outskirts were in our hands. The paralyzing effect of the heavy bombardment was immediately apparent, and good progress was made against gradually increasing enemy resistance. By the evening our troops had penetrated to the northern parts of the town, where heavy hand-to-hand fighting developed. The infantry fought with little heavy support, as for the whole of the day tanks were unable to enter the shattered town as the roads into CASSINO were so damaged and blocked with masonry. Extensive R.E. work was therefore necessary. The town itself was in ruins and as the enemy began to recover from the effects of the bombardment his snipers appeared in the houses and made it impossible for the sappers to clear the streets.

The first afternoon's fighting had yielded important results and the stage was now set to exploit these during the night, taking advantage of the enemy's disorganization and using the light of a bright moon to regroup and continue the advance. The plan was for the leading brigade to complete the mopping up of CASSINO, whilst another brigade proceeded to capture MONTE CASSINO. Up to this time the operation had developed, more or less, according to plan, but in the evening the weather broke and torrential rain fell during the night. The advantage of the moon was lost and visibility reduced to a stage where, hampered as they were by mud-filled craters and crumbling debris, the infantry could make no further progress. This was unfortunate, for it enabled the enemy, who had the advantage of superior knowledge of the streets and buildings, to reorganize and reinforce a number of strong points. Communications deteriorated, for the rain and mud affected many of the wireless sets carried by the infantry, and the laying and maintenance of wire was hampered by sniping from buildings in the town. Rain collected in the bomb craters, and to clear the road for tanks it was now necessary to bridge each individual crater, often under intense mortar fire.

(ii) *Operations 16th March*

The fighting on 16th March was confused, and in the town the enemy held out in a number of strong points. During the morning, however, six tanks found an alternative route into the town from the north and destroyed a number of sniper's positions. By the evening the infantry had reached the area of the CONTINENTAL HOTEL, where a strong enemy position covered Highway 6 to the east and south.

(iii) *Operations 17th March*

At dawn on the 17th March the tanks attacked the enemy in the southwest corner of the town. Fighting continued throughout the day. The enemy resisted stubbornly and the situation remained very confused. The enemy's knowledge of the town and its defenses, and his superior observation, enabled him to put down heavy and accurate mortar fire on the attacking infantry. On our side, supporting fire for the attack was difficult to provide due to the lack of knowledge of the progress of our forward troops, while tanks were still restricted in their movements. By evening, although some progress had been made, the enemy still held a number of strong positions in the town, including the CONTINENTAL HOTEL. The attack on the railway station was more successful, however, and by evening it was occupied by our infantry.

(iv) *Operations 18th–23rd March*

Infantry and tank attacks on the CONTINENTAL HOTEL and other strong points in the west of the town continued for a further five days against ever stiffening resistance without any appreciable success. On 23rd March, it was finally decided to abandon the attempt to capture the town, as it was clear that success could only be achieved at the cost of heavy casualties and by using up the reserves for further projected operations.

16. Considering the nature of the fighting, casualties were not excessively heavy. Firing the assault immediately after the air and artillery bombardments they amounted to less than 200 killed and wounded, while during the remainder of the operations up till the with-

drawal they amounted to 1,316 killed and wounded in the town.

RESULTS

17. A considerable part of the town was taken and a fair number of prisoners captured. Nevertheless the operation failed to achieve the results intended. The bombing destroyed most of what still remained standing among the houses of the town except for a fringe round the edge. The chief damage was caused by rubble, which blocked the entrances to cellars and caused a number of the enemy to be trapped. Evidently posts were abandoned to take cover, as prisoners of war stated that machine guns in the open had to be abandoned as it was not possible to get them under cover. On the other hand, the stronger defenses did not appear to have been seriously affected. One mobile pillbox, however, was moved bodily by a near miss but the occupants were not hurt. Enemy communications were completely disrupted, but the town was under good observation from the slopes above. All roads were heavily cratered and blocked with fallen debris. Where the ground was low, and even on the higher ground, after the rain started the craters filled with water. These had to be bridged to enable tanks to get through.

18. It has been hoped that the heavy scale of bombardment might have produced a high degree of demoralization among the defenders. Although a special psychiatric report rendered after the operation was over stated in general terms that the bombing had only slight effects upon the Germans mentally, some of the early prisoners questioned in the first 24 hours, however, hold the view that the bombing had had a very decisive effect. It had come as a complete surprise, and although they were prepared for an intensive artillery barrage and for bitter street fighting, they had no conception of having to endure intensive air bombardment as well. To sum up, it would be fair to say that although the enemy recovered rapidly they were undoubtedly shaken and disorganized for a certain period of time. In this connection, it should be pointed out that the German troops concerned came from a Paratroop Division with high morale.

19. A more marked effect might have been caused, however, if the bombing had been more accurate and continuous and concentrated into a shorter period of time. The combined effect of bad bombing and poor timing by the Heavy Bombers resulted in intermittent attacks on the target, with appreciable periods of rest which enabled the defenders to recover before the attacks were resumed.

20. Although the weather was suitable for the initial bombardment, it was unfortunate that it turned unfavorable at the end of the first day's operations. Up to nightfall considerable progress had been made and it is reasonable to assume that had the fine weather continued throughout that night and the following day, complete success might have been achieved. The bad weather, however, seriously hampered our movement and allowed the enemy to reorganize and consolidate his position.

CONCLUSIONS

21. Although the operation failed in its desired object, it is possible to draw certain reasonable conclusions from the results achieved. These may be categorized as follows:

(i) Under certain circumstances a heavy scale of air bombardment can assist materially in softening up defenses to facilitate their capture by infantry. Employed in close support of a ground operation, however, air bombardment cannot be expected to obliterate strong defenses and determined resistance, and it must always be realized that air bombardment can only be supplementary to the ground attack. The infantry must close with the enemy to achieve final victory. There is no substitute for the infantry.

(ii) In order to produce the maximum effect on enemy morale, bombing must be continuous and strict attention paid to timing of the attacks. Where, however, targets are of a limited area and calm air conditions prevail, it will not normally be practicable to compress attacks into less than fifteen minute intervals as smoke and dust will obscure the target. These intervals should, however, be reduced to the absolute minimum

(iii) The size of the force used must be governed by the ability to find and hit the target hard for a stated period, and not by the

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desire to drop an arbitrary weight of bombs. Heavy Bombers, accustomed to a strategic role, may not be sufficiently accurate to attack close support targets, unless they are unmistakable or can be clearly marked by artificial means.

(iv) The ground attack, which must be aggressive, determined, and at maximum available strength, must be launched immediately the bombardment ceases. The stunning effect can only be temporary and the enemy must not be given sufficient time to recover his shattered senses. Owing to the heavy damage to roads by cratering and fallen debris, it will seldom be possible to employ tanks and armored vehicles for some considerable time afterwards. Their participation in the immediate attack should not therefore be considered. Heaps of rubble and half destroyed buildings will also provide the enemy with advantageous firing points and positions for defense. The maximum amount of infantry was not employed in this operation, nor was the attack aggressively pushed. Too much reliance was placed on the ability of the bombardment to eliminate the opposition.

(v) Such operations must be regarded as "combined" operations in the true sense of the word. Each arm has a particular part to play and every operation of this kind must be studied and planned on an interservice basis.

Signed (Name illegible)
Major General,
Commanding General,
M. A. T. A. F.

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ENCLOSURE C

THE BATTLE OF EL ALAMEIN

by
A. D. Coox and W. Wells

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THE BATTLE OF EL ALAMEIN

OBJECT

The object of this study is to determine whether or not the British or the Axis could have made effective tactical use of an atomic bomb at El Alamein.

CONCLUSIONS

In this enclosure conclusions are given for four situations, based on four totally different assumptions. In the first situation it is concluded that 3 atomic bomb explosions would have prevented the British in ordinary uniforms from executing an effective offensive, while 5 atomic bomb explosions would have incapacitated up to 100 percent of the effective forces. In situation two it is assumed that British troops would have been equipped with special uniforms and conclusions are that 10 atomic bombs would probably have been sufficient to prevent their offensive, while 12 atomic bombs would have been sufficient to incapacitate more than 50 percent of the men massed for the attack.

In situation three it is concluded that there was an incident of concentration at the breakthrough point in which the employment of a 20 KT atomic bomb, suitably placed by the Axis, would have broken the strength of the British attack However, the proximity of Axis troops in battle contact with the British would have made the decision to use an atomic weapon very difficult in view of the inaccuracy of whatever method of delivery was chosen.

In the fourth situation it is concluded that the use of one 20 KT atomic bomb by the British at the attack salient would have cleared a path probably sufficient to effect a breakthrough immediately thereafter. One additional 20 KT atomic bomb, suitably placed over two Axis divisions, would probably have led to rapid consolidation of the breakthrough with subsequent encirclement of the remaining Axis forces.

HISTORICAL DATA ON THE CAMPAIGN OF EL ALAMEIN MILITARY, ECONOMIC, AND POLITICAL CONSIDERATIONS

To the desert-weary Axis Army of North Africa, the fertile Nile Delta would be a welcome haven. Beyond lay the Suez Canal, classic link in the British life-line of empire. Capture of the delta could mean the final denial of the eastern Mediterranean to the Allies, domination of Egypt and the other Middle Eastern lands—a decisive step in the vast Axis pincers movement affecting Allied aid to the USSR; and great stores of oil from Iraq and Iran.

The Allies, on the other hand, required desert victory to destroy the enemy forces in Libya, to put an end to this see-saw battle of advance and retreat to Benghazi and to win great influence over the French, by a quick and spectacular success, in connection with the forthcoming operations in northwest Africa.

GEOGRAPHICAL CONSIDERATIONS

The region of El Alamein station presented peculiar tactical problems in the north. Salt lagoons which border the Mediterranean give way to a sandy coastal strip on which the rail line and roads to Alexandria run. In the center of the 40-mile position there are ridges and rocky hills covered with a thin layer of sand. Farther south, rock out-croppings are more frequent and finally fall away abruptly into the Qattara Depression, which formed the southern anchor of the line.

The ground itself was very flat; therefore, there were few observation posts with any appreciable command of the surrounding country. Special difficulties were presented by the absence of well-defined features and landmarks, for determining objectives and maintaining direction (see Figure 26).

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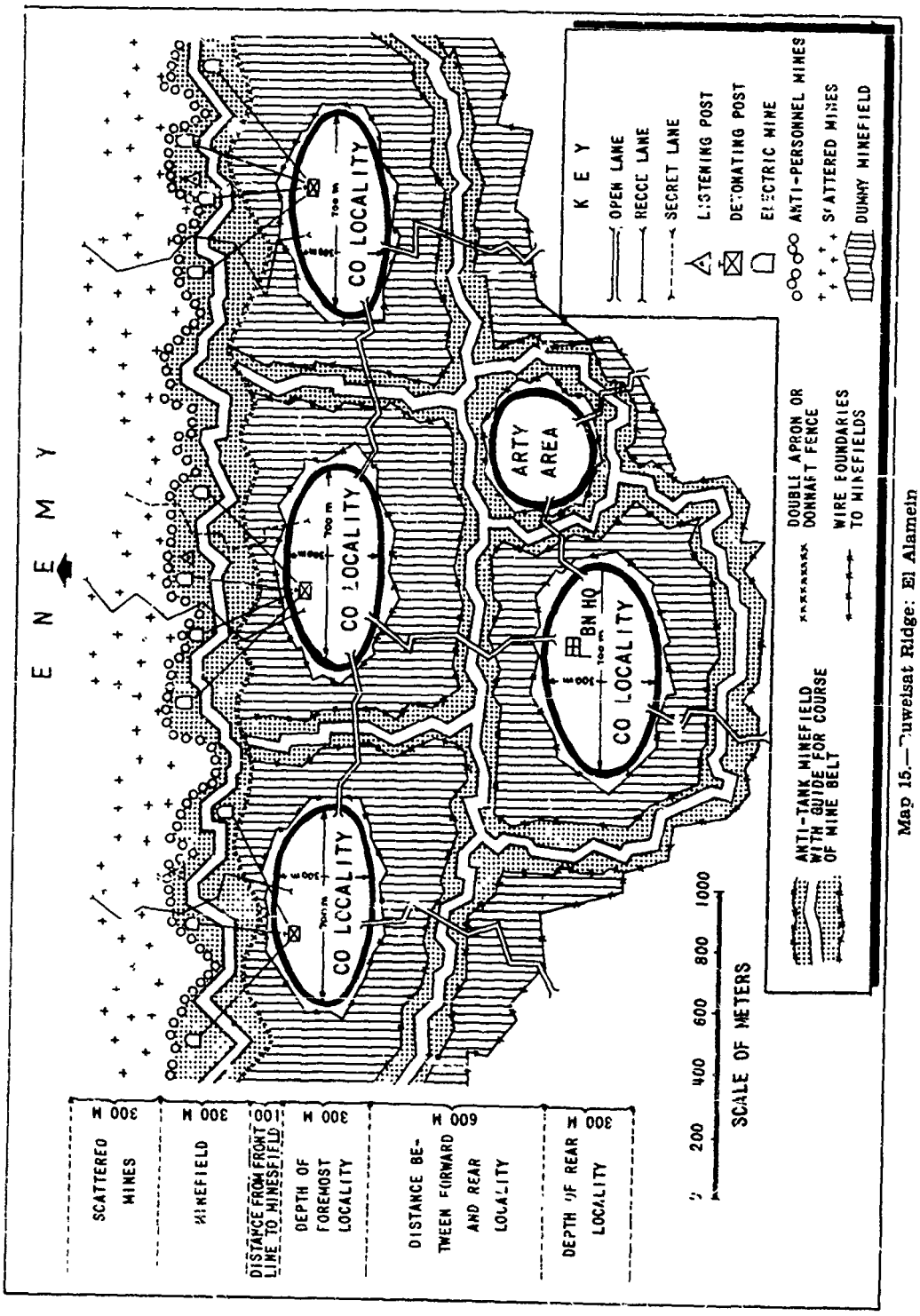

Map 15.—Tuweisat Ridge: El Alamein

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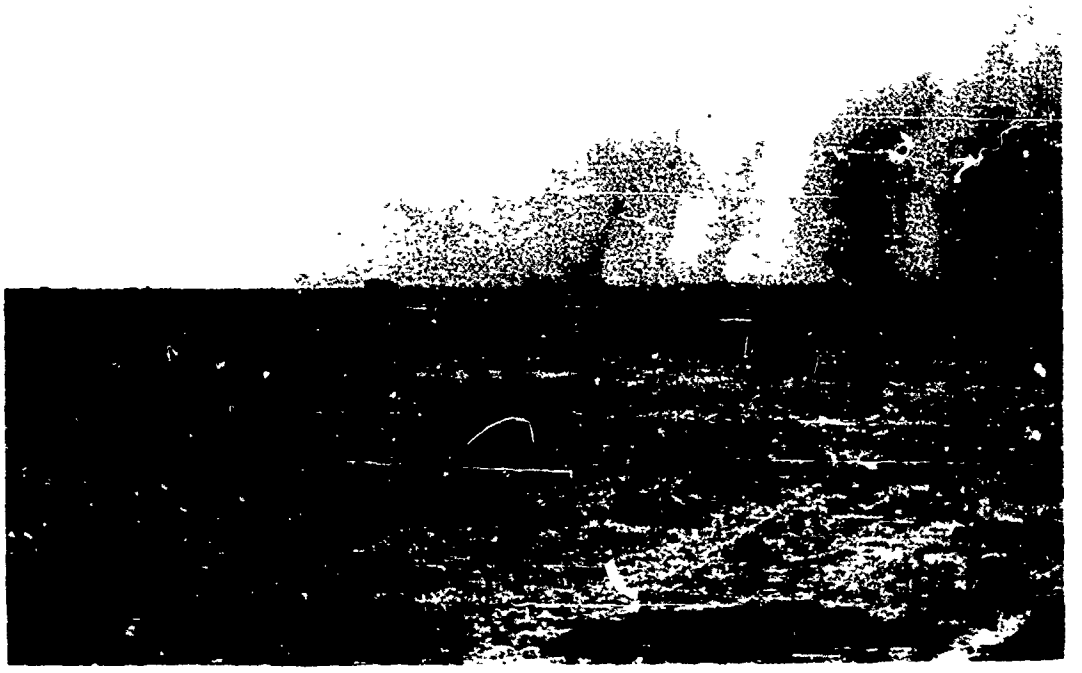

Figure 26.—Sand Storm in the Desert near Alamein

The enemy's southern defenses were strongly wired, but, by comparison, the northern sector's defenses were not particularly formidable as to wiring (see Map 15).

Strategic surprise was therefore impossible. How to gain tactical surprise? The date, weight, and true direction of the attack must be concealed from the enemy. Ruses and camouflage were employed on an extensive scale, with wireless traffic coordinated to support false concentrations. "Phantoms" were created; real massings hidden. Forward assembly areas, often in full view of the enemy, had to conceal motionless troops for many hours, in shelter slits, without hot meals. Dummy pipelines, dummy vehicles and armor, et cetera—all led the Axis to believe the blow would fall in the southern sector. The success of Allied tactical surprise is summed up in this German study captured later in Tunisia:

> Camouflage in the battle area was effected in so masterly a fashion by the disposition of dummy vehicles in already abandoned bivouac and concentration areas that air reconnaissance was completely deceived.

Nature was needed to provide a further requisite for offensive action: moonlight before dawn. As early as 15 October, the moonlight factor permitted operations on a large scale.

On 23 October it was clear and fine. Temperatures were about 28° C (82.4° F).

LOGISTICAL PROBLEMS OF THE EIGHTH ARMY

The magnitude of the logistical problem was caused primarily by several factors:

Base ports were 14,000 miles away by sea from the home base. Very large reserves of supplies, reinforcements, and stores of all types, had to be built up well before the battle.

Large dumps had to be established in the forward area before the offensive. Seven days' reserve supplies were dumped behind the lines in the northern sector; five days' supplies, in

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the south, and four days' stocks were held in reserve.

There was a single-track railway. West of El Alamein there were serious harbor problems. The huge distances necessitated a very large number of vehicles, with attendant traffic control problems along the one good coastal road.

The forward areas of the 8th Army at El Alamein were only 60 miles from Amiriya, which, together with certain base depots in the Alexandria area, constituted the advanced base for the entire army at that time. Many desert tracks had to be built by the British, up to XXX Corps' starting line, through very soft sand. This was in addition to the many large dummy dumps in the southern sector, and the dummy pipeline and water installations (Map 16).

Before the offensive, railheads to serve the El Alamein defenses were established at Burg el Arab (supplies, ammunition, engineer stores, ordnance stores, salvage); at Bahig (fuel); at Amiriya (personnel, vehicle and tank delivery and recovery); Gharbaniyet, 3 miles west of Burg el Arab (ambulance); and at Ikingi Maryut (RAF).

In addition to supplies the following reserves were built up at 8th Army operational dumps:

Fuel: 500,000 gallons for X Corps.

Ammunition: 25-pounder, 268,000 rounds (including 95,000 for Operation Supercharge); 4.5 inches, 12,800 rounds; 5.5 inches, 6,400 rounds; and other, four days, at 8th Army rates.

Ordnance stores: engines, track and suspension assemblies for X Corps; weapons and other urgent fighting stores for army; clothing reserves

At the railheads, stocks of 3 days' average issue of supplies, ammunition, and fuel were built up.

Additional ammunition holdings were stored at:

Dikheila (Alexandria west); 4th AAD; 14,000 tons.

Alexandria, 4th AOD; 7 days at double 8th Army rates.

Kilo 101, on Cairo to Alexandria road, two days at 8th Army rates for 1 armored division; 1 armored brigade group; 1 infantry division; and XIII Corps troops.

Two "en cas mobile" trains, each approximately 650 tons, were held in the delta, their location being frequently changed as a precaution against sabotage and possible aerial detection.

At the peak period of build-up, 1–23 October, a daily average of over 2,500 tons was delivered at army railheads.

After D plus 1, new railheads were constructed on schedule. El Imayid was to be the first of these railheads from D plus 1. El Alamein was to follow as soon as the tactical situation allowed.

Thus, the El Imayid railhead was opened on 27 October for ammunition and salvage. On 5 November El Alamein became the railhead for supplies, fuel, Royal Engineer stores, and ordnance stores.

Hamman was to operate for vehicle delivery and recovery; Amiriya for personnel; Gharbaniyet for ambulance; Ikingi Maryut for RAF.

Construction trains worked on a shuttle service from Gabbary, the marshalling yard at Alexandria.

Reserves of fuel were to be held at Amiriya, and a restock at Dikheila. A pool of tank cars was kept ready and loaded in Alexandria.

At the 6th AOD, Alexandria, specially selected ordnance stores were held for immediate call by the 8th Army. These stores included: tank and motor vehicle spares, signal equipment, gun parts, optical stores, small arms, spares, barrels, et cetera.

In the forward fighting areas, replenishment of first-line vehicles was used satisfactorily in infantry formations during the advance.

Ammunition, rations, water, and petrol trucks remained in the area from which the fighting troops had moved forward. Second-line vehicles replenished first-line vehicles as early as possible in the morning. First-line vehicles then moved off to follow up the fighting troops.

Under this system, unit vehicles were able to find the route by daylight. The number of vehicles to go forward from the assembly areas to the objectives, in each of the forward

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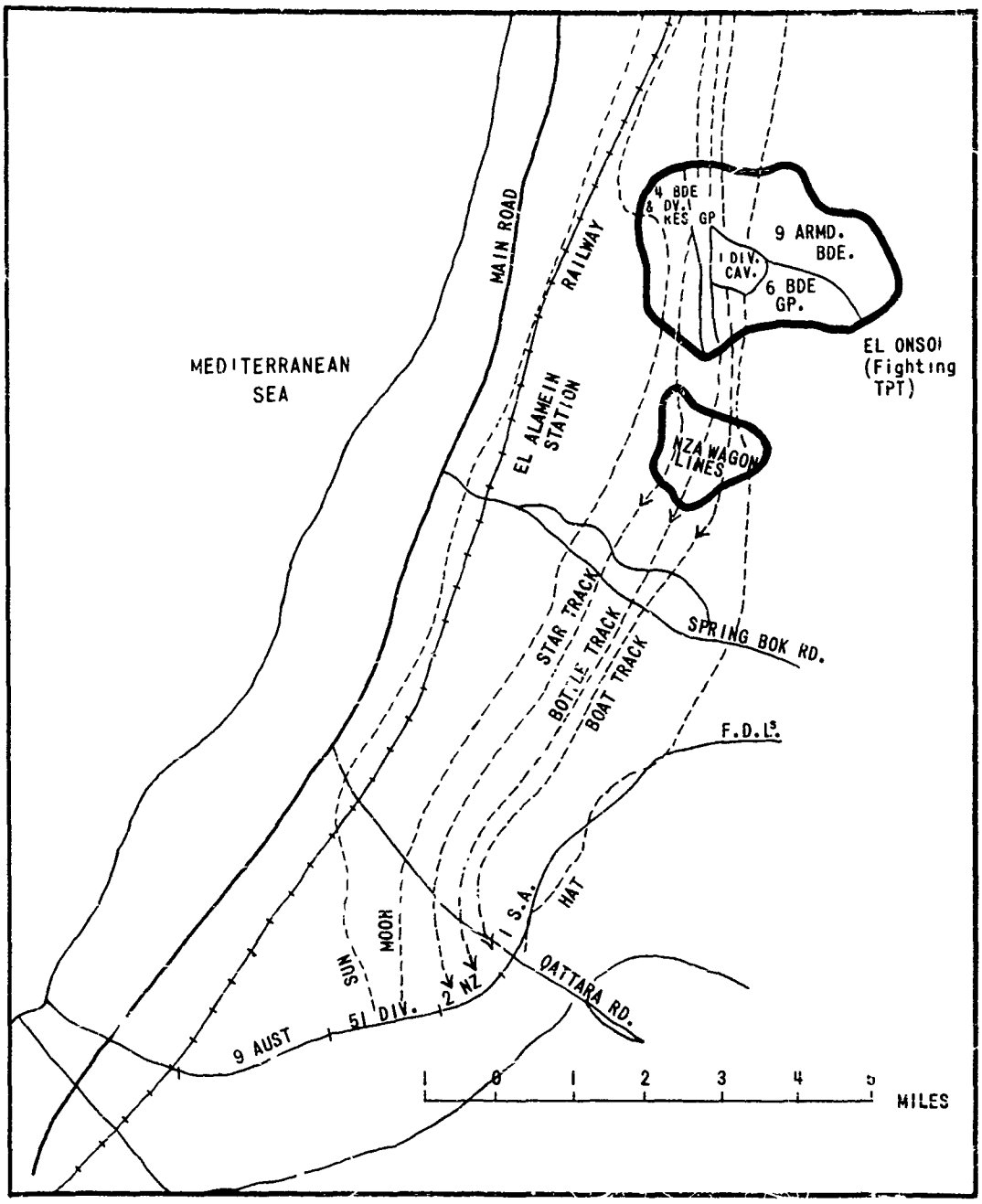

Map 16.—30th Corps Front, First Light, 23 October 1942, Showing Division Sectors Routes Forward and Assembly Areas 2nd New Zealand Division

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brigades, totalled some 100 (apart from the 150 tanks and 52 vehicles of the divisional cavalry). To reduce the number of vehicles on the desert tracks during the main attack, 3 days' rations and water were dumped or carried, in addition to the normal reserves on the fighting vehicles.

Logistics. Example 1 (from a map of the Tobruk Advance Base).

Unit	*Area (sq mi)*
Advanced Ammunition Depot	7.6
No. 2 Sub-Depot AOD	1.3
Personnel Transit Camps	3.0
Medical Area 1	2.5
Medical Area 2	0.2
Fuel Depot	2.3
Engineer Stores	0.38
Bulk Petrol Filling Center	0.13
No. 3 Sub-Depot AOD	0.1
121st Maintenance Unit	1.3
Base Supply Depot	0.23
Workshops	0.1
Air Field	0.6
Motor Transport Convoy Area	14.0

Logistics. Example 2 (from a map of Benghazi Advance Base).

Unit	*Area (sq mi)*
Personnel Transit Camps	1.3
RAF 124 Mobile Unit	0.4
Advanced Ammunition Depot	1.2
Fuel Depot	1.1
Fuel Depot Extension (Salvage)	0.3
Base Supply Depot	0.1
AOD (includes Captured Stores Depot)	0.2
Workshops	0.15
Air Field	0.63
Motor Transport Convoy Area 1	0.3
Motor Transport Convoy Area 2	0.5
Engineers	0.1
Rendezvous Point	0.05

Logistics. Example 3 (from a map of the Tripoli Advance Base).

Unit	*Area (sq mi)*
Personnel Transit Camps	1.5
Engineers	0.3
Advanced Ammunition Depot (includes RAF)	3.0
Fuel Depot (includes RAF)	2.4
Vehicle Reception Point	0.4
AOD	0.5
Signal Park (8th Army)	0.06

OPPOSING FORCES 23 OCTOBER

AXIS (See Map 17)

Ground Forces

Axis ground forces consisted of 93,500–96,000 men, of whom, slightly more than 50 percent were German. There were six Italian and two German infantry divisions. The latter were the 60th Light Division and 164th Light Africa. These divisions' organization each had 3 infantry regiments of 2 battalions, with 4 rifle companies in each battalion. (Note: In Europe, German battalions normally had only 3 companies.) The 164th was very weak in artillery, and suffered from deficiencies in men and materiel. It had 9,000 men at the beginning of the battle, a number which decreased to 3,500 within 4 weeks. The 21st Panzer Division had 12,500-13,000 men in its southern group; 5,600-6,500 in its northern group. (These strengths were reversed geographically after 25 October.)

The following is an itemization of the weapons available to the 164th Light Africa Division on 23 October:

8539 Rifles
2721 Pistols
732 Machine pistols
385 Light machine guns
105 Heavy machine guns
95 Light tank weapons (PzBn)
68 Light mortars
63 Heavy mortars
55 3.7cm Pak
93 5cm Pak [19]
18 Light assault guns
3 Heavy assault guns
4 7.5cm Pak
12 Light field howitzers
4 10cm Cannon
6 Heavy field howitzers
3 8.76cm Cannon

Armor

Two panzer divisions and two Italian divisions comprised the armor of somewhat over 500 tanks. Forty percent were Mark III or Mark IV and 60 percent Italian vehicles. The 15th and 21st Panzer Divisions each had 1

[19] These Pak guns were divided as follows: Panzer Grenadier Regiment 125 had 31; Panzer Grenadier Regiment 382 had 27; Panzer Grenadier Regiment 433 had 29; Reconnaissance Group 220 had 6

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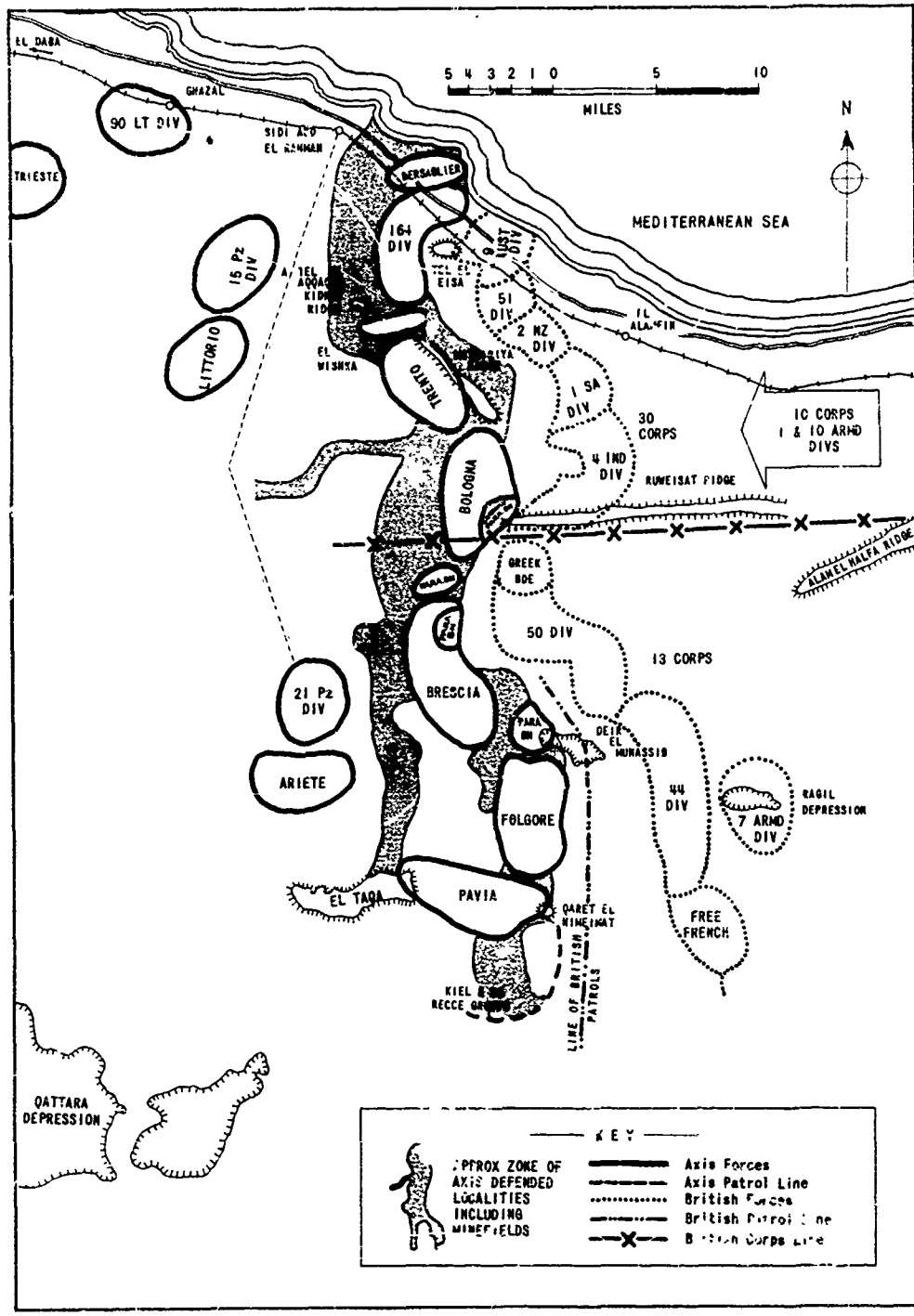


Map 17.—The Battle of El Alamein, 23 October–3 November 1942

tank regiment of 2 battalions and 1 mechanized infantry (Panzer Grenadier) regiment of 3 battalions.

Antitank Artillery.—At El Alamein the Axis armor was intermingled. In the northern sector, opposite the 1st and 10th British Divisions, there were three groups of 80–100 tanks each. These groups comprised 1–2 tank battalions from the 15th Panzer and Littorio Divisions; 1–2 infantry battalions from the same; and a proportion of field, assault, and antitank guns. Only one of these groups seems to have been assigned a mobile role. (See Map 18.)

In the south, two mixed groups of 80–100 tanks each faced the 44th Division.

The Axis also formed a reconnaissance group of 3 squadrons, with the reconnaissance units from the 2 panzer divisions and 90th Light Division. It consisted of an armored car squadron, infantry in armored troop carriers, a heavy squadron of antitank guns, close-support artillery, and a pioneer platoon. Two of the units also had independent troops of captured British 25-pounder guns.

On 23 October, the Germans had:

Mark II Tanks	30
Mark III	80
Mark III S	86
Mark IV	8
Mark IV S	30
Staff Tanks	4
Total	238
Armored Cars	152
Motorcycles, et cetera	864
Trucks	7249
Captured Vehicles	4081
Total	12346

The Italians had:

Medium Tanks	279
Light Tanks	20
Total	299
Armored Cars	42
Motorcycles, et cetera	439
Trucks	2587
Vehicles	113
Total	3181
Axis Assault Guns	35

Note. 20–30 percent of all vehicles were constantly under repair.

Armored Divisions:

21st Panzer (23 October):

	Tanks
Mark II	19
Mark III	53
Mark III S	43
Mark IV	7
Mark IV S	15
Staff Tanks	6
Total	143
Hq, Afrikakorps	7

Of the 21st Panzer tanks, 43 were under repair and 18 had been lost by 29 October.

Littorio Division (23 October):

Medium Tanks	70
Light Tanks	20
Total	90

15th Panzer Division (23 October):

	Effective	*Repair*
Mark II Tanks	12	2
Mark III	38	5
Mark III S	43	1
Mark IV	2	1
Mark IV S	15	–
Staff Tanks	1	–
Total	111	9

On 23–24 October, 20 tanks were lost; 12 more were lost by the 29th; 44–45 additional tanks were under repair, 24–29 October. The 15th Panzer Division had the following artillery available:

5cm Pak	70
8.8cm Flak	8
10cm Cannon	4
10cm Field howitzer	24
15cm Field howitzer	8
15cm Assault gun	4
Captured 8.76cm	5
Captured 5.7cm Pak	4
7.62cm SP	16
15cm SP howitzer	8
Italian guns (in battle group, from Littorio Division)	41

Scale in Miles

0 1 2 3 4 5 6

1

NORTHERN BATTLEGROUP

Commander: Col. Crasemann, 33 Pz. Artillery Regt.
Troops: Hq., Pz. Artillery Regt. 33 (plus Staff Battery)
1st Bn., 115 Pz. Grenadier Regt.
2nd Bn., 33 Pz. Artillery Regt.
3rd Flak Co., 617 Bn.
2nd Pz. Bn., Section, 133 Regt. (Italian)

RESERVE DIVISIONS

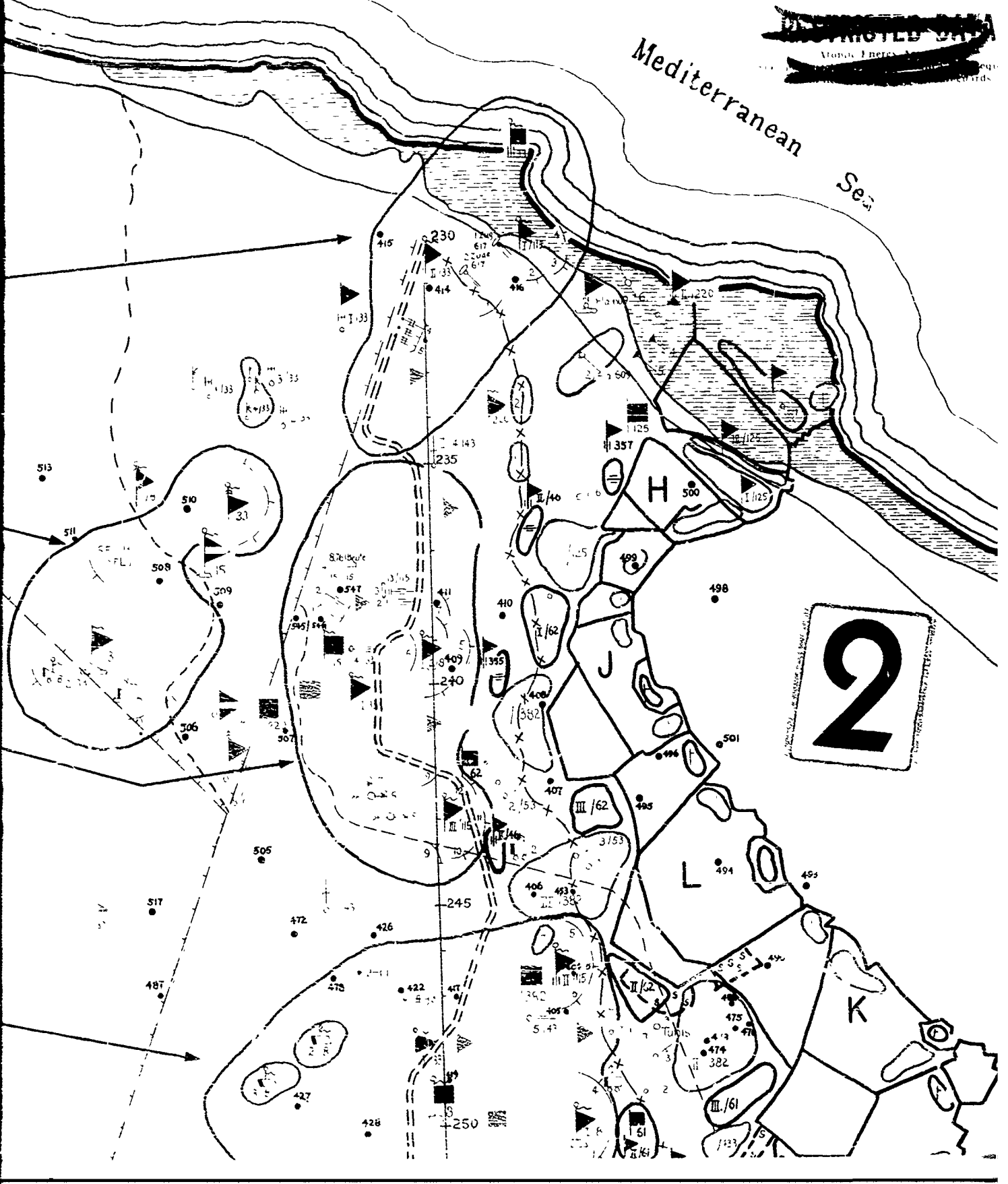
Commander: Capt. Hinrichs, 33 Pz. Pioneer Bn.
Troops: 33 Pz. Pioneer Bn.
3 Pz. Infantry Unit

CENTER BATTLEGROUP

Commander: Maj. Schemel, 115 Pz. Grenadier Regt.
Troops: Hq. & hq., Co., 115 Pz. Grenadier Regt.
2nd Bn., 8 Pz. Regt.
3rd Bn., 115 Pz. Grenadier Regt.
13th Infantry Co., 115 Pz. Grenadier Regt.
3rd Bn., 33 Pz. Artillery Regt.
Italian Hq., 133 Pz. Regt.
Italian 4th Pz. Bn., Section, 33 Pz. Regt.
Italian 23rd Bn., 12 Bersaglieri Regt.
Italian 29th Bn., 3 Artillery Regt.
Italian Assault Gun Section 556.

SOUTHERN BATTLEGROUP

Commander: Col. Teege, 8 Pz. Regt.
Troops: Hq., 8 Pz. Regt.
1st Bn., 8 Pz. Regt.
2nd Bn., 115 Pz. Grenadier Regt.
1st Bn., 33 Pz. Artillery Regt.
Italian Hq., 12 Bersaglieri Regt.
Italian 12th Pz. Bn., Section, 133 Regt.
Italian 26th Bn., 12 Bersaglieri Regt.
Italian 2nd Bn., 3 Artillery Regt.
Italian Assault Gun Section 554.


Mediterranean Sea
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H
J
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K
230
235
240
245
250

Key

- 15 and 21 Panzer Divisions
- Italian Troops with 15 and 21 Pz. Divisions
- 164 Light Infantry Division
- Italian Troops in 164 Light Infantry Sector

Hq Corps Motorized

Hq Infantry Division

Hq Panzer Division

Hq Infantry Regiment

Hq Artillery Regiment in Panzer Division

Hq Infantry Bn

Hq Mountain Infantry Bn

Hq Infantry Bn in Panzer Division

Hq Engineers Bn Motorized

Hq Panzer Reconnaissance Bn

Hq Artillery Bn

Hq Artillery Bn in Panzer Division

Antitank Company Motorized

Antitank Company Selfpropelled

Engineers Company Motorized

Antitank Platoon Motorized

Hq Rifle Company

Battery 88mm antiaircraft guns

Battery 20mm antiaircraft guns

Selfpropelled battery 20mm antiaircraft guns

Light antiaircraft position

Battery 75mm assault guns

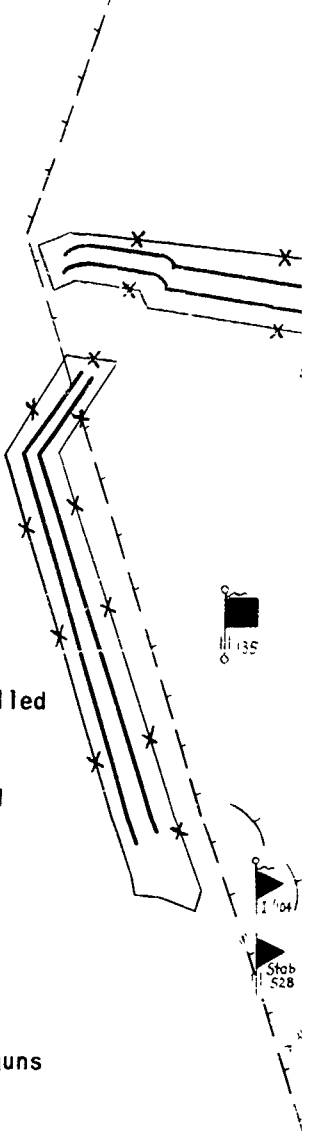
Battery 88mm guns emplaced

Battery light mountain guns

Battery 100mm guns emplaced

Battery 105mm howitzers 18 emplaced

Battery 150mm heavy field howitzer 18 emplaced



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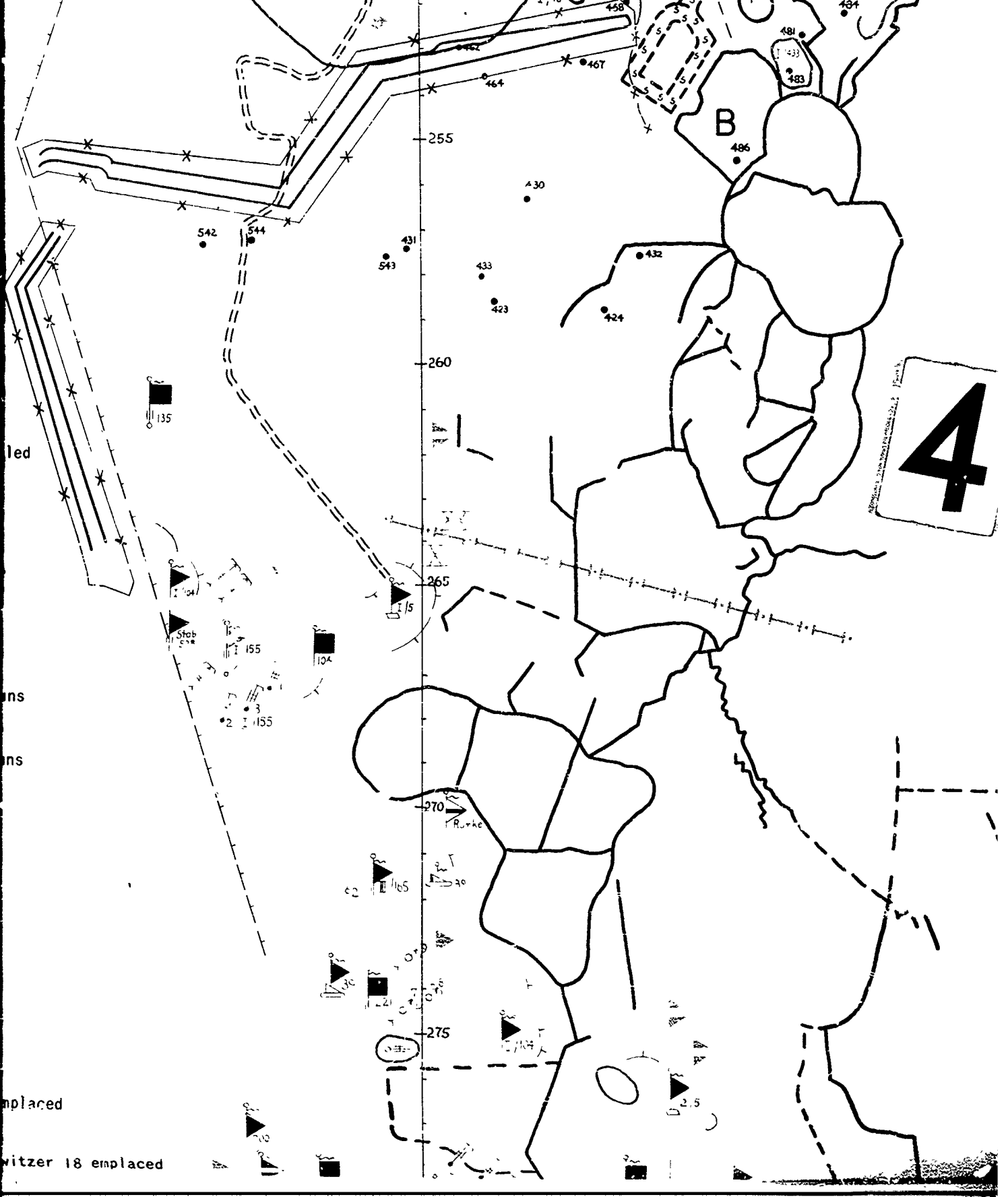
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Hq Infantry Regiment

Hq Artillery Regiment in Panzer Division

Hq Infantry Bn

Hq Mountain Infantry Bn

Hq Infantry Bn in Panzer Division

Hq Engineers Bn Motorized

Hq Panzer Reconnaissance Bn

Hq Artillery Bn

Hq Artillery Bn in Panzer Division

Hq Antiaircraft Bn

Hq Selfpropelled Antiaircraft Bn

Hq Panzer Bn

Hq Antitank Bn Selfpropelled

Antitank Platoon Motorized

Hq Rifle Company

Battery 88mm antiaircraft guns

Battery 20mm antiaircraft guns

Selfpropelled battery 20mm antiaircraft guns

Light antiaircraft position

Battery 75mm assault guns

Battery 88mm guns emplaced

Battery light mountain guns

Battery 100mm guns emplaced

Battery 105mm howitzers 18 emplaced

Battery 150mm heavy field howitzer 18 emplaced

Battery 150mm heavy field howitzers 13

Battery selfpropelled heavy infantry howitzers

Antiaircraft searchlight

Entrenched armored units

Gun position

Telephone and Teletype Station or Meteorological Sta

Trail

Corps boundary

500

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Map 18—Axis situation, 23 October 1942,

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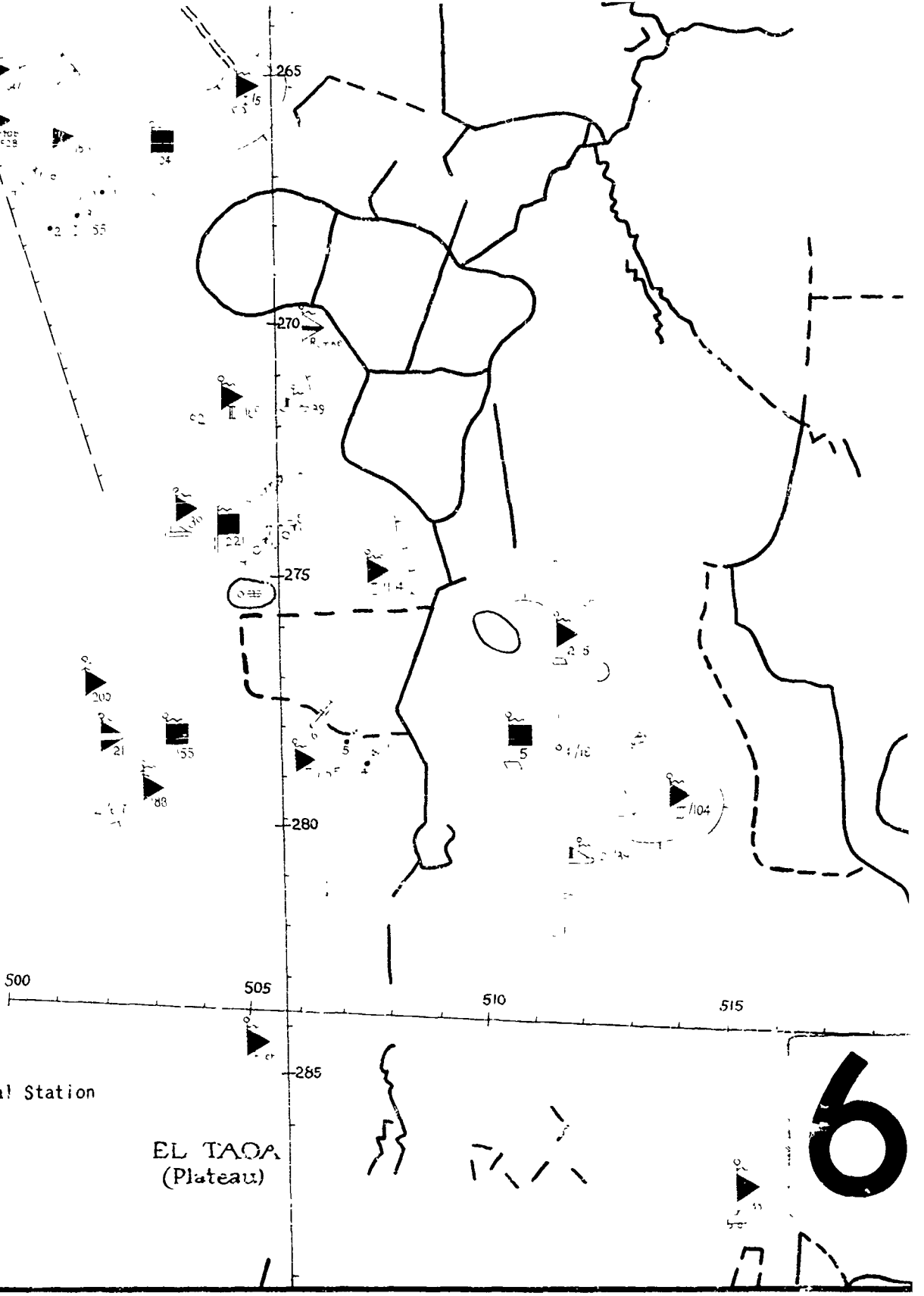

—Axis Situation 23 October 1942 2045 Hrs

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Artillery

Artillery consisted of about 400 guns, 900 antitank weapons, and 50 88mm dual purpose guns. In the British XXX Corps Zone, the enemy was believed to have in action about 200 field guns, 40 mediums, and 14 heavies. As will be shown later, these 25 batteries or so were subjected at El Alamein to British concentrations of up to 20 to 1.

Air Forces:

Fighters and fighter-bombers	347
Bombers	277
Seaplanes	36
Reconnaissance and utility	53
Total	[20] 713

ALLIES (Map 17)

Ground Forces

Ground forces consisted of 150,000–177,000 men. The XXX Corps contained 14 infantry brigades, 1 (New Zealand) armored brigade; the XIII Corps had 7 infantry brigades, 1 armored division, 2 armored brigades, a French flying column (2 battalions of Foreign Legion, and Spahis). The X Corps consisted of 2 armored divisions, 2 (New Zealand) brigades. Altogether they totalled 7 infantry divisions, 3 armored divisions; and armored brigades.

Armor (excluding replacements):

Sherman Tanks	267
Grants	128
Stewarts	128
Crusader (6-pounder)	105
Crusader (2-pounder)	255
Crusader (Close Support)	35
Valentines	196
Total	1,114

Units present: the X Corps consisted of the 1st Armored Div, 2nd Armored Brig, 10th Armored Div, 8th Armored Brig, and the 24th Armored Brigade. The XIII Corps had the 7th Armored Division, 4th (Light) Armored Brigade, and the 22nd Armored Brigade. The XXX Corps contained the 9th Armored Brigade, and the 23rd Armored Brigade.

[20] Includes Greece, Sicily, and Crete based.

British Armor Situation, 23 October

Note. The following figures refer to effective tanks actually with units and formations on this date.

9th Australian Div Cavalry Regt	17
40 Bn, Royal Tank Regt (under command, 1–26 October inclusive, and on 31 October)	44
	61
51st Highland Div 50 Bn, Royal Tank Regt (under command)	36
2nd New Zealand Div	
9 Armored Brigade	122
2 NZ Div Cavalry Regt (armored cars)	62
8 Bn, Royal Tank Regt (under command)	44

Note. The 9th Armored Brigade on 23 October was an integral part of the 2nd New Zealand Division, which had only 2 infantry Brigades.

4th Indian Div	none

British Artillery Situation, 23 October

9th Australian Division: Normal Divisional Artillery:

	Guns
3 Field Regts (each of batteries, each of 2 troops)	72
1 Antitank Regt (of 4 batteries, each of 4 troops)	64
1 Light Antiaircraft Regt (of 3 batteries, each of 4 troops)	48
Additional artillery under command of the 9th Australian Division, 16–31 October, consisted of:	
6 Troops of 146th Field Regiment (guns only, but no battery or regiment staff)	24
Total Artillery	208

51st Highland Division: Normal Divisional Artillery:

3 Field Regts (each of 3 batteries, each of 2 troops)	72
1 Antitank Regt (of 4 batteries each of 4 troops)	64
1 Light Antiaircraft Regt (of 3 batteries, each of 4 troops)	48

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TABLE XIV
SUMMARY OF BRITISH ARMOR, 23 OCTOBER

FORMATION	VALENTINE	SHERMAN	GRANT	CRUSADER MK. II	CRUSADER MK. III	CRUSADER CLOSE SUPPORT	STUART	TOTAL TANKS	ARMORED CARS		
									Daimler	M-H	Total
9th Austr. Div.	11			13			4	61			
51st Highland Div	36							36			
2nd NZ Div		36	37	29	12	8	29	151			
1st S A. Div	44							44	4	58	62
4th Indian Div											
Total	124	36	37	42	12	8	33	292	4	58	62

NOTE In addition, the 51st Highland Division had a composite squadron of carriers. All infantry battalions had as an integral part a platoon of carriers, varying in strength, but no exact figures are available. The Field Artillery Regiments of Divisional (not additional) Artillery had a number of "Armored OP's" which might be armored cars, carriers, Stuart tanks, or armored trucks Numbers and types varied considerably.

TABLE XV
SUMMARY OF ARTILLERY, 23 OCTOBER

FORMATION	FIELD ARTILLERY			ANTITANK		TOTAL	LT AA TOTAL	TOTAL GUNS
	Div	Add'l	Total	6-pdr	2-pdr			
9th Aust Div	72	24	96	64		64	48	208
51st High Div	72	12	84	48	16	64	48	196
2nd NZ Div	72	24	96	59		59	48	203
1st S.A Div [1]	72	12	84	48	16	64	48	196
4th Indian Div	48		48	54	10	64	48	160
Total	336	72	408	273	42	315	240	963

[1] The 1st South African Division had in addition 3 18-pounders and 6 50-mm used as antitank guns.

Additional artillery under command from 17–24 October from the 1st Armored Division was.

3 Troops of the 28th Field Regiment (guns only) 12

Total Artillery 196

2nd New Zealand Division: Normal Divisional Artillery:

3 Field Regts (each of 3 batteries, of 2 troops) 72

1 Antitank Regt (of 4 batteries, each of 4 troops)[21]

1 Light Antiaircraft Regt (of 3 batteries, each of 4 troops) 48

Additional artillery under command, 17–24 October, from the 1st Armored Division was:

3 Troops of 98th Field Regt and 3 Troops of 78th Field Regt (guns only) 24

Total Artillery 203

1st South African Division: Normal Divisional Artillery:

3 Field Regts (each of 3 batteries, of 2 troops) 72

1 Antitank Regt (of 4 batteries, each of 4 troops) 64

1 Light Antiaircraft Regt (of 3 batteries, each of 4 troops) 48

Additional artillery under command, 17–24 October, from the 10th Armored Division was:

3 Troops of 98th Field Regt (guns only) 12

Total Artillery 196

[21] Division had 59 6-pounders, of its establishment of 64 6-pounders

[redacted]

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Use Military Classification Safeguards

4th Indian Division: Normal Divisional Artillery:	
3 Field Regts (each of 2 batteries, of 2 troops)	48
1 Antitank Regt (4 batteries, each of 4 troops)	64
1 Light Antiaircraft Regt (of 3 batteries, each of 4 troops)	48
Total Artillery	160

In addition to the figures in Table XV, which relate only to artillery units, there were the following 2-pounder antitank guns in the possession of formations. These guns formed the armament of antitank platoons which were integral parts of their respective battalions. The normal establishment was 8 guns per battalion, or 24 per infantry brigade.

	Guns
9th Australian Division	80
51st Highland Division	72
2nd New Zealand Division (which had 2 Infantry Brigades only, instead of 3)	60
1st South African Division	48
4th Indian Division	72
Total	332

Note. Field Guns 25-pounder
Antitank 2-pounder or 6-pounder
Light Antiaircraft 40-mm Bofors

Artillery (excluding replacements) of entire 8th Army:

25-pdr (field) (3.45 inch or almost 88mm)	832
4.5 inch (medium)	32
5.5 inch (medium)	20
105-mm (field) ("Priests")	24
	908
6-pdr (antitank)	753
2-pdr RA (antitank)	105
2-pdr Inf (antitank)	416
	1,274
4.2 inch CW Mortars	12

Note. Divisional artillery CP's were very simple and mobile. The 2nd New Zealand Division's CP had 1 3-ton lorry and 3 Dodge 8-cwt trucks. Regimental CP's had 1 staff car and 1 dug-out. Since medium artillery was a favorite Stuka target, these troops always deployed in a diamond or square formation, with the guns 100–150 yards apart. To avoid exhaustion of personnel, the gun crews were increased in size before the battle started.

Air Forces

The air force consisted of 500 fighters and 200 bombers.

AERIAL EFFORT

The RAF had gained almost complete air superiority by 23 October. This, together with the ineffectiveness of the enemy's artillery, enabled the British to concentrate a far greater number of guns and vehicles in a small area than would have been justifiable without such superiority.

Beginning on the night of 18–19 October, the Allied air attack stepped up its tempo and ran well over 700 sorties daily. The 8th Army attack was definitely withheld until the RAF command on 25 October gave positive assurance of complete domination of the air.

After the September battles, prior to the opening of the British offensive, air activity in the Middle East battle area was restricted due to the scarcity of targets resulting from the absence of full scale ground fighting and need for both sides to build up serviceability. During the period 6 September–22 October, the RAF made the following attacks: 24 medium bombers; 77 light bombers; and 341 fighter-bombers plus low-flying fighter attacks on lines of communications behind the enemy's front.

On the night of 23–24 October, 66 Wellingtons and 24 Albacores attacked continuously in the northern and southern sectors, concentrating on enemy gun positions, armor, and encampments. Thirty night-flying Hurricanes (from Squadron 73) strafed ammunition trucks, field guns, ammunition dumps, vehicles, transport, and repair shops.

On 24 October, a record number of light bomber sorties was flown against enemy vehicles. In all, 14 attacks were made, 174 sorties being made by Bostons and Baltimores, and 48 by Mitchells. These sorties were supported by escorting Kittyhawks and P-40's. These attacks met the heaviest antiaircraft

activity, 5 Bostons and 1 Baltimore being destroyed and 7 Bostons and 3 Baltimores being seriously damaged. Twelve Hurricane IID's escorted by Hurricanes destroyed 18 tanks on El Taqa Plateau. There was constant fighter patrol over the battle and forward areas by Spitfires and Hurricanes and constant cover for the assembled armor.

On 24–25 October, 69 Wellingtons and 16 Albacores attacked enemy transport in the northern sector and Squadron 73 of Hurricanes strafed the central and southern areas.

On 25 October, 7 light bomber attacks were made by 96 Bostons and Baltimores, with 24 Mitchells, 46 fighter-bomber sorties and continuous fighter patrols by Spitfires and Hurricanes; they shot down 6 ME 109's, 1 MC 202, damaged 4 ME 109's and 8 fighters, with a loss of 1 Kittyhawk. US P–40's destroyed 3 German fighters and damaged several others.

On 25–26 October, the Wellingtons and Albacores attacked enemy transports.

On 26 October, there were 7 attacks by 100 Bostons and Baltimores, 22 Mitchells' and escorting Kittyhawks on concentrations of troops in the northern sector. Independent attacks were made by 30 well-escorted Kittyhawks, and light bomber attacks were made on air fields. Tank busters of Squadrons 6 and 7, South African Air Force, in the south got 4 tanks and 2 armored cars. Seventeen enemy fighters were shot down, 13 damaged, and 9 probably destroyed. The RAF lost 4 fighters.

During the night of 26–27 October, the medium bombers continued their nightly attacks in the northern sector and also bombed the Adi Haneish landing grounds in order to limit the enemy's night bomber effort. Night-flying Hurricanes also carried out offensive patrols over these enemy landing grounds.

On 27 October, ten attacks on enemy concentrations were made by 177 escorted RAF and USAAF bombers. In the meantime, fighter-bombers attacked another concentration of enemy transport in the central and southern sectors where the flak was less formidable. Additional bomber activity indicated successful attacks on the docks and railways at Matruh and the landing ground at Fuka. Total enemy losses during the day were 7 bombers and 11 fighters destroyed, 7 bombers and 1 fighter probably destroyed, and 5 other aircraft damaged. RAF losses were 4 fighters and 1 Baltimore shot down.

On 28 October, the last day on which enemy land forces took the initiative, 7 attacks were made in an area 3 miles by 2 miles against tanks and vehicles. Sixty three Baltimore sorties, 39 Boston sorties, and 24 Mitchell sorties were flown with an escort of 108 Kittyhawks, 39 P–40's, and 12 Hurricanes. The RAF shot down 9 planes, probably destroyed 3 more, damaged 6, and lost 2 fighters. The USAAF shot down 4.

For this last period, 24–28 October, Allied air sorties averaged 811. October 24, the first day of battle, was the peak: 952 sorties. Twenty-five planes were missing when the phase ended.

ALLIED ARTILLERY EMPLOYMENT AND THE BATTLE OF EL ALAMEIN

For any major attack, no restriction was placed on ammunition expenditure. Except for the initial attack, when ample time for preparation was available, the limiting factor was the ability of the second line and unit transport to bring up what was required. The divisions on the front of the main attack were never limited in ammunition, but after the first 2 days, the divisions on the southern and central parts of the front in both corps were limited to 40 rounds per gun per day.

To provide for this tremendous outlay of shells, elaborate and concealed dumping programs were initiated. Each gun position was to dump 620 rounds per gun during darkness, in the days before the battle. Thus, the 2nd New Zealand Division's Ammunition Company spread its program over nights. For the 96 guns under its command, 12,096 rounds per night were dumped each of the first 4 nights. On the fifth night, 11,000 25-pounder and 8,000 Bofors ammunition rounds were cached. To accomplish this, the ammunition trucks were loaded with only 68 rounds per gun each, the first 3 nights, so that one gun per troop could be completed each of those nights.

On the northern sector, for more than 2 weeks prior to the attack, a silent counter-battery policy was adopted, except for certain destructive firing against particularly active

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enemy batteries, and neutralization firing against roving guns.

In the main attack, set for the night of 23–24 October, the frontage of attack was some 7,000 yards, for the 4 divisions engaged. Support was to be provided by 360 25-pounders and 48 medium guns. There were only 3 regiments of the latter (2 of mixed 4.5-inch and 5.5-inch batteries, one of 4.5-inch guns alone), so all were used for the main attack in the north, under CCRA, XXX Corps. In addition, some 48 25-pounders were available from 4 Indian divisions for the initial phases. The concentration of 25-pounders was thus about 1 gun per 17 yards of frontage of attack.

Inasmuch as the attack was to advance to a depth of about 4,000 yards, the fire plan took the form of concentrations on all prepared defensive localities, the fire lifting from locality to locality at an average rate of 100 yards in 3 minutes. In 2 localities where Axis defenses were less well defined, support took the form of barrage, with an average rate of fire of 2 rounds per gun per minute

For 20 minutes before zero hour for the infantry attack (1940–2000 hours GCT), an unprecedented counterbattery neutralization opened up. At various phases of the attack, up to 4 field regiments and 3 medium regiments were used on counterbattery tasks, but at other times all available guns were concentrated on the enemy's forward positions.

The counterbattery fire kept up after the normal artillery plan had ceased. The medium artillery program lasted for 5½ hours, but the guns fired more or less continually for 20 hours, and the ammunition expenditure was over 300 rounds per gun.

The Australian infantry division was supported by its own 3 field artillery regiments and 1 medium artillery regiment; and 1 attached medium artillery regiment, besides the fire assistance of the 2 neighboring divisions at times.

The New Zealand division had 4 field regiments and 1 medium battery; totalling 104 guns. The front of fire was 2,500 yards, as first objective (1 gun per 24 yards). This arc widened to 4,800 yards, as final objective (1 gun per 46 yards). As this was not really sufficient for an artillery barrage, the program provided for 25 percent of the guns (1 per 100 yards of front) to fire on a barrage line to keep the infantry on its proper line of advance. The remaining 75 percent of the guns were to fire timed concentrations on known enemy defenses. This division's infantry had assembled on a start line 1,700 yards from the enemy positions, the 5th New Zealand Brigade attacking on the right, the 6th New Zealand Brigade on the left. The 9th Armored Brigade followed Closest to the assaulting infantry were the 25-pounders. The remaining 25-pounders were posted farther behind, furnishing the heavy barrage, while 800 yards behind the front of the barrage were the medium artillery. Zero hour was 2000 hours All 4 divisions attacked simultaneously, between 298 and 285 grids (approximately 8 miles of total frontage and 4 miles of depth). Owing to the dust and smoke raised by the artillery barrage, visibility was no greater than 20–30 yards.

In the assault waves attacking across the minefields were the division's rifle companies; 20 officers and 400 men Behind came the heavy weapons carriers; 15 officers and 330 men.

In the subsidiary attack carried out by the XIII Corps in the south, support was provided by a mixture of barrage and concentration, preceded as in the XXX Corps' operation by concentrated fire for 30 minutes on Axis batteries and located antitank guns. As previously mentioned, no medium artillery was available here.

Several smaller attacks were launched, generally supported by concentrations of fire. The 51st Highland Division was supported primarily by X Corps artillery. Depth of all attacks went to 4,000 yards. The initial attack took 3 hours, in addition to counterbattery fire.

To the extreme north, the 24th Australian Brigade of the 9th Australian Division made a feint attack between Tel El Eisa and the coast. Support was furnished by a chemical warfare mortar company, firing HE shells. Only 2 of this company's 3 sections (US squads) could be deployed. These 12 4.2 inch mortars were allotted all of the available 1,600 rounds of HE shells. The mortars fired for 4 hours, averaging 133 bombs per piece fired during the night.

One regiment of Royal Artillery was equipped with US-manufactured 105mm gun-howitzers mounted on medium tank chassis (the British Priests). These vehicles were used for immediate support of armor alone, and moved up with the latter. Priests were not included in any of the artillery night actions or day concentrations at El Alamein. Ammunition expenditure totalled 18,000 rounds.

The total number of 25-pounder rounds fired during the period 23–24 October to 4–5 November was over 1,000,000 rounds. Average expenditure of 25-pounder ammunition was 102 rounds per gun per day, through this 12-day period.

Over the same length of time, the medium artillery fired an average of 133 rounds per gun per day (4.5-inch guns) and 157 rounds per gun (5.5-inch guns).

Supplementary Artillery Actions

The initial attack on 23–24 October may have seen the most spectacular employment of artillery in the desert by the British, but other succeeding major concentrations are worthy of note in the next 12 days of fighting

On the night of 30–31 October, the 26th Australian Brigade launched an attack northward. The field artillery of 3 infantry divisions and 1 armored division lent support, in addition to 1 field regiment and 3 medium regiments. A total of 260 guns was employed.

The 151st Brigade (50th Division) and 152nd Brigade (51st Division), backed by the 9th and 23rd Armored Brigades, attacked on a 4,000-yard front on the night of 1–2 November; the depth was 6,000 yards. Before this important offensive (known as "Supercharge"——just as the initial operations were known as "Lightfoot"), the artillery opened fire primarily in a creeping barrage by moonlight. Since little was known of the enemy's defenses, and since adequate guns were available, an absolutely straight barrage commenced on the forward grid line, and moved exactly at right angles to the opening line to a depth of 4,000 yards at the rate of 100 yards per 2½ minutes. The barrage did not extend beyond the frontage of the infantry attack The troops themselves were withdrawn to a line of cairns 1,700 yards behind the grid line

The artillery units engaged were the field artillery of the 2nd New Zealand Division, 51st Highland Division, 1st Armored Division, 10th Armored Division, plus 1 regiment from the 9th Australian Division, and 2 medium regiments. Fire was placed in concentrations on known and likely enemy localities in the barrage lane, and on the flanks of the barrage up to about 2,000 yards on each side. The number of guns employed in the barrage were: 192 (or 1 25-pounder per 21 yards of barrage frontage); on centrations: 168 (or 1 field or medium gun per 22 yards over the total 8,000 yards covered by the fire plan).

The average rate of fire was 2 rounds per gun per minute As before, the infantry attack was preceded by concentrations of all available guns on hostile batteries. In 4½ hours, 15,000 rounds were fired. The total number of guns engaged was 300 25-pounders and 20th Corps medium artillery.

Two nights later, the 5th Indian Infantry Brigade was supported in its attack by 10 field regiments and 2 medium regiments, totalling 270 guns.

CASUALTIES

During the first 24 hours of the battle (i.e., by 2200 hours, 24 October), 839 casualties passed through the New Zealand division's medical stations alone. These figures include British and South African wounded (See Table XVI.)

By 1800 hours, 25 October, the 8th Army had taken only 1,400 prisoners on the whole XXX Corps front (nearly one-half Germans). Of this total, the New Zealanders took 260 prisoners.

Casualty evacuation arrangements for the battle, based upon an estimate of casualties expected, had been as follows:

	Normal Sick	*Battle Casualties*
D minus 3	330	20
D minus 2	400	20
D minus 1	450	20
D Day	350	500
D plus 1	300	2000
D plus 2	300	2000
D plus 3	300	2000
D plus 4	300	1000
D plus 5	300	1000
D plus 6	300	1000
D plus 7–9	300	500

[redacted]

[redacted]

Actual admissions to British central collecting stations and field ambulances were:

	Sick	Battle Casualties
August 1942	10,649	449
September	10,417	1,470
October	11,141	7,634
November	8,698	3,602
December	7,196	632

By 11 November (when the pursuit to Fuka began), the Allies had suffered 13,500 casualties: 12 percent killed, 63 percent wounded, 25 percent missing. Four hundred thirty-two tanks had been lost to enemy action, but most were repairable. The X Corps lost 50 percent of its tanks in the first 3 days.

At the same date, the Germans had lost 34,000 killed, wounded, and prisoners of the Italians, 25,000. About 500 tanks had been destroyed in battle or captured and demolished.[22] At least 400 guns had been captured and 600 destroyed. Many thousands of lorries littered the dunes.

An example of the losses of an Axis infantry division is seen in the casualties suffered on 21–31 October by the 164th Light Africa Division: 178 dead; 507 wounded; 1,896 missing; 659 sick; 3,240 total.

As noted previously, the division's manpower dwindled from 9,000 to 3,500 by 20 November. For example, the 125th Panzer Grenadier Regiment then had only 454 men left; the 382nd Panzer Grenadier Regiment, 455; the 433rd Panzer Grenadier Regiment, 1,157.

NOTES ON THE EMPLOYMENT OF ARMOR IN THE DESERT

It was learned early that dispersion was the sole means of protecting motor vehicles and installations from enemy air activity in the desert. Larger areas covered large spaces, generally at least 200 yards between vehicles.

Defensive operations presented special problems Holding a ridge from hull-down positions, there was always the danger of artillery concentrations against the ridge itself, with resultant heavy casualties. Therefore, to avoid these casualties, one tank per troop was kept forward to observe. The remainder of the tanks lay behind the ridge until called forward into fire position. Individual tanks were stationed at 50-yard intervals, with 100–150 yards between troops.

In the attack, the 23rd Armored Brigade with 4 regiments (1 per infantry division in the XXX Corps) normally allotted 1 tank battalion to 1 infantry battalion. In an area cleared of mines, tanks attacked by day on a front of about 800 yards, and a depth of 400 yards. The same tank battalion attacked by night on a front of 400 yards, and a similar depth.

TABLE XVI
EIGHTH ARMY CASUALTIES, 23–26 OCTOBER
(0600 HOURS)

FORMATION	OFFICERS	OTHER RANKS	TOTAL
9th Australian Division	62	1,006	1,068
51st Highland Division	96	1,860	1,956
2nd New Zealand Division	62	860	922 [1]
1st South African Division	51	542	593
4th Indian Division	2	75	77
	273	4,343	4,616

[1] 2nd New Zealand Division's figures include the 9th Armored Brigade, which was a part of the division

Note The ratio of killed to wounded averaged about 1 in 5 The 4th Indian Division may have been rather below establishment. No returns on fighting strengths are available

The tank and infantry battalions, attacking together, covered an 800-yard front by moonlight and a 400-yard front by starlight. The tank squadron and an infantry company, attacking by moonlight, covered a 400-yard front. The maximum depth might be as much as 1,500 yards in any case.

PRESSURE POINTS AT EL ALAMEIN

Certain special considerations enter into the possible use of an atomic weapon at El Alamein. Contour height at the areas of bitterest fighting was no more than 50–70 meters. The terrain was generally flat with no cover for infantry. The troops wore knee-length shorts in addition. After the 20-minute artillery barrage, a very heavy pall of smoke cut down visibility, and hung in the air.

[22] 253 were lost at El Aqqacir (2 November) to X Corps; plus 222 guns.

[redacted]

Atomic bombs delivered on the XXX Corps at 2200 hours, 23 October, would have caught 4 divisions in an area of 8 miles by 4 miles, at the breakthrough point. About 30,000 men were involved therein: the 51st Highland, 2nd New Zealand, and parts of the 9th Australian and 1st South African Divisions. Two hundred ninety were operating with these divisions as well.

The main attacks were made by infantry brigades of the XXX Corps. Before the offensive, the equivalent of 4 infantry and 3 armored divisions were concentrated behind a front 8–10 miles wide. Much of the area was unsuitable for *la guerre de manoeuvre*, and congestion in the assembly areas behind the minefields was very great. From the initial assembly line along the track south of El Alamein Station, British armored columns rumbled forward, in 2 paths 1,500 meters wide. The 2nd New Zealand Division had moved up from its concentration area at Alam el Onsol to the Bir El Makh-Khad area (Maps 16, 19, and 20).

By dawn of 24 October, the 2 armored divisions of the X Corps had entered the salient made the previous night by the main infantry attack on a front 12 kilometers wide and 6 kilometers deep. Various armored divisions and brigades remained in this salient until the final breakthrough occurred. The situation was thus peculiar in that the 2nd Corp was deployed in a rather small area, in which there was considerable congestion. Specifically by 1000 hours on 24 October, the 1st Armored Division was right behind the 51st Highland Division and the 9th Australian Division. The armored column cleared a gap for itself and went through. These formations were then in a wedge about 6 miles at the broadest point, narrowing to an apex of little more than ½ mile. With the rifle strength of the infantry divisions still largely up to strength, a real pressure point had developed. For later, during the period of the widening of the initial bridgehead in the fighting at El Alamein, the drain on rifle companies became so heavy that it was not uncommon for the bayonet strength of a battalion to be reduced to no more than 150–200 men.

The psychological effect of an atomic air burst might therefore have greatly aggravated the normal command problems of the dawn breakthrough. The problem of destroying the infantry divisions *before* the armor attacked would be weighted by the defender, against the merit of catching bunched-up mixed formations prior to decisive exploitation.

Inasmuch as the opposing lines were 3,000 yards apart, and because the terrain was generally flat, it would be advisable that friendly troops in ordinary uniforms in the open withdraw about 5,000 yards from the aiming points of an atomic weapon.

Destruction of the 164th Division and Trento Division by atomic weapons would have opened up a wide path for the X Corps armor, and would have obviated operation Supercharge.

Axis armored and artillery concentrations were generally insufficient for quantitatively profitable attack. But the X Corps itself may have provided a rare case of the target of opportunity while in its staging area to the south of El Alamein Station. The diamond-shape deployment of the artillery made the latter much less susceptible to mass-destructive attack.

The peculiar logistical problem of the region (one single-track railroad, one coastal road, tracks through soft sand) made supply of fuel and ammunition critical. For instance, 5 days of ammunition were cached in the lines, 4 days in operational dumps, 3 days in railheads, 7 days in additional holdings, 60 miles away. The base depots were 120 miles from the front. The necessity for a tremendous build-up of this ammunition supply indicates that if the transportation links could have been repeatedly knocked out, and certain installations disrupted, insufficient ammunition stores would have been available by 1 November. Operation Supercharge could not then have been initiated, nor a break-out produced.

EFFECT OF ATOMIC WEAPONS

The disposition of the British forces under General Montgomery and the Axis forces under General Rommel on 23 October 1942 are shown in Map 17, which duplicates General

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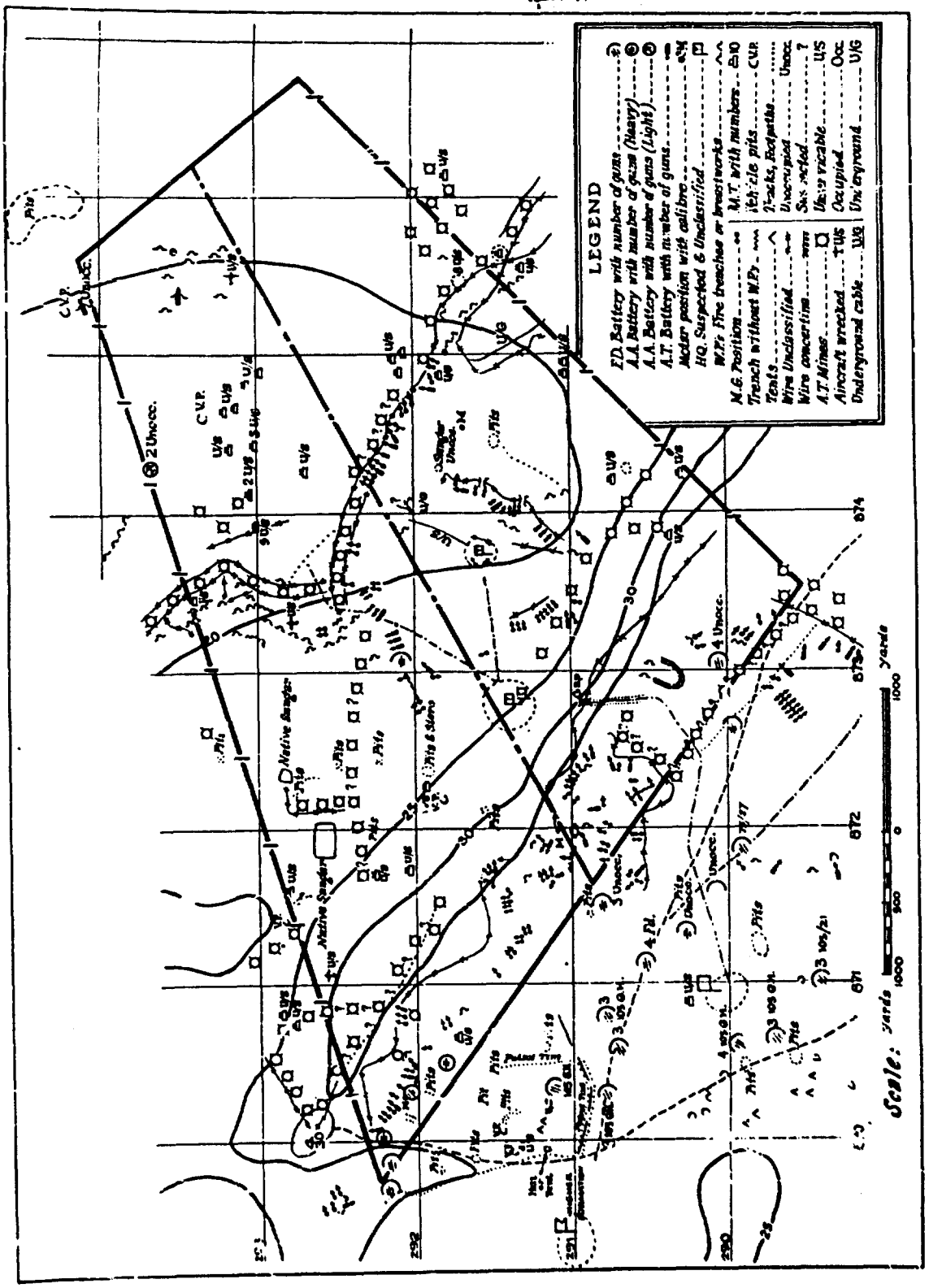
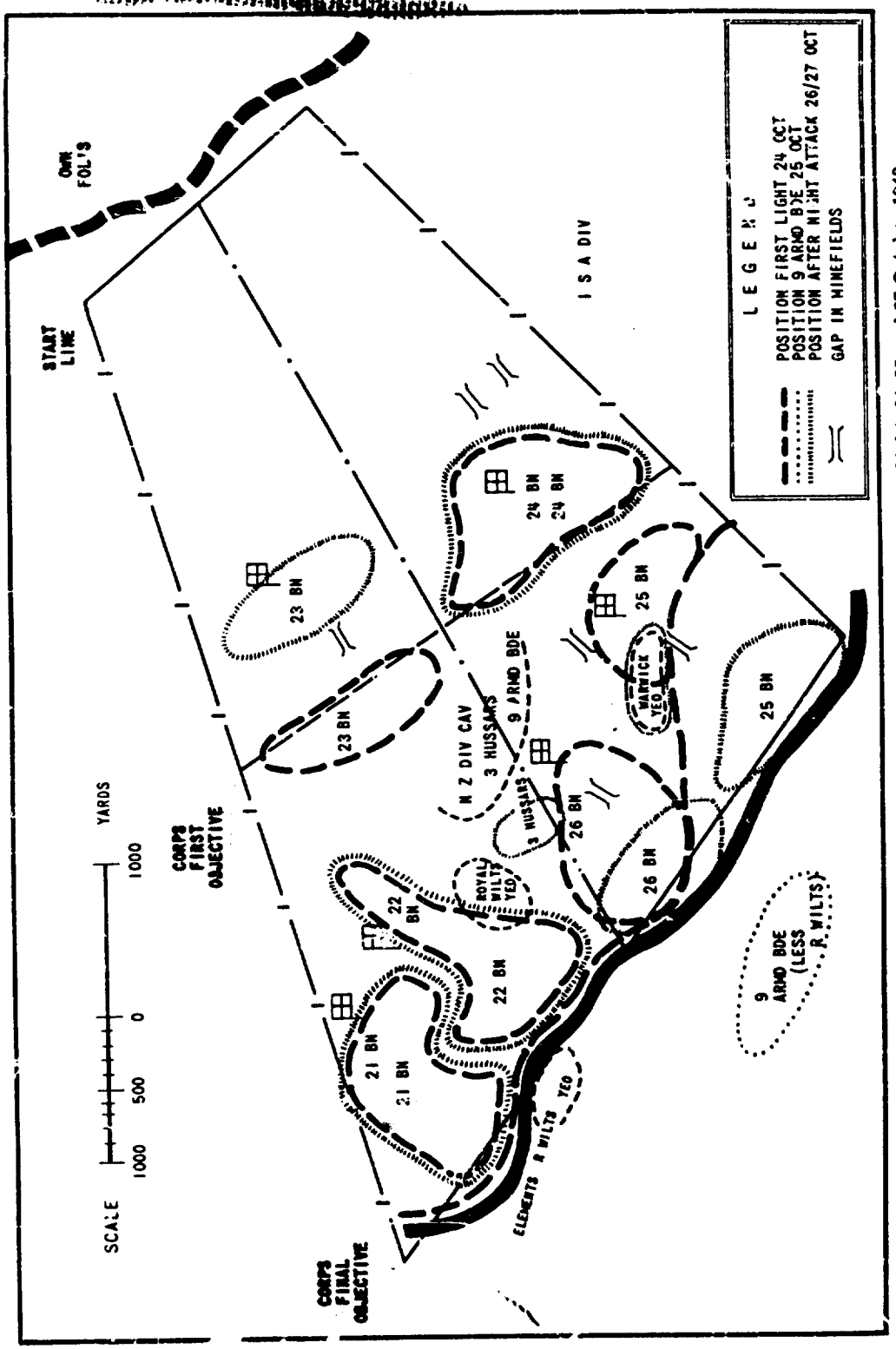


Map 19—Enemy Defenses 2nd New Zealand Division Sector, Prior to Attack, 23 October 1942



Map 20.—2nd New Zealand Division Sector, Showing Situations at First Light, 24, 25 and 27 October 1942

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Montgomery's own map. Only approximate information is available on the number of men in the various divisions of the 30th Corps and 13th Corps, and from this information Table XVII gives a reasonable estimate of the distribution of manpower along the front just prior to the decisive British assault.

An estimate of the disposition of men among the various groups of the Axis forces is given in Table XVIII.

For the purpose of this analysis, which is to indicate the effect of atomic weapons in this situation, meaningful conclusions can be drawn even though exact information is not available on the distribution of the men. The pertinent situations will be discussed under several assumptions as to the protection which the men may have had and might conceivably have had *if* they had knowledge of the possibilities of atomic weapons being used.

FIRST SITUATION

ASSUMPTIONS

The Axis troops were in the defensive position indicated and expected an attack in strength.

The Axis had 20 KT atomic bombs, air burst.

The British were massing for an attack in strength.

The British did not have preknowledge that atomic bombs would be used.

The disposition of men on both sides was as shown on Map 15.

TABLE XVII
DISTRIBUTION OF ALLIED MANPOWER

UNIT	NO. MEN
9th Australian Div	13,000
51st Div	13,000
2nd New Zealand Div	9,300
1st South African Div	12,000
4th Indian Div	8,000
10th Corps, 1st and 10th Armored Div	34,000
Greek Det	1,500
50th Div	10,000
44th Div	10,000
Free French	2,500
7th Armored Div	10,000
	131,300

TABLE XVIII
DISPOSITION OF AXIS MANPOWER

UNIT	NO. MEN
Trieste Motorized Inf Div	4,500
90th Light (Motorized) Inf Div	7,300
15th Panzer Div	13,000
Littorio Armored Div	6,000
Bersoglieri	1,500
164th Light Inf Div	9,000
A small unit near Kidney Ridge	900
Trento Inf Div	7,000
Bologna Inf Div	6,000
Brescia Inf Div	6,000
21st Panzer Div in two units:	
Southern Unit	13,000
Northern Unit	6,000
Folgore Inf Div	5,000
Pavia Inf Div	4,500
Kiel and 33rd Recce Groups	2,500
Ariete Armored Div	5,500
	97,700

The Axis men were warned of the time of the projected use of the atomic weapons and were in fox holes, the case upon which Figure 25 is based.

The British infantrymen massing for attack were disposed essentially in the open, the case upon which Figure 27 is based.

The personnel of the British armored vehicles were in the open as they were massing but not in battle positions.

Approximately 2,000 yards separated the opposing lines.

Under these assumptions the following consequences of this situation are obtained:

From the curves of immediate incapacitating casualties, with ordinary uniforms for troops in the open, out to a radius of 3,500 yards from the bomb center of a 20 KT bomb burst 600 yards above the ground there would be about 25 percent incapacitation. The terrain was quite flat and devoid of trees. Three 20 KT bombs spaced about 8,000 yards apart along a line between the coastal position of the 9th Australian and the Ruweisat Ridge would be expected to incapacitate about 25 percent of the 9th, 51st, 2nd New Zealand, 1st South African, and 4th Indian, i.e., 25 percent of 55,800 or 13,950 men. After the Battle of Alamein, the total British casualties to 11 November were 13,000 killed, wounded, and missing.

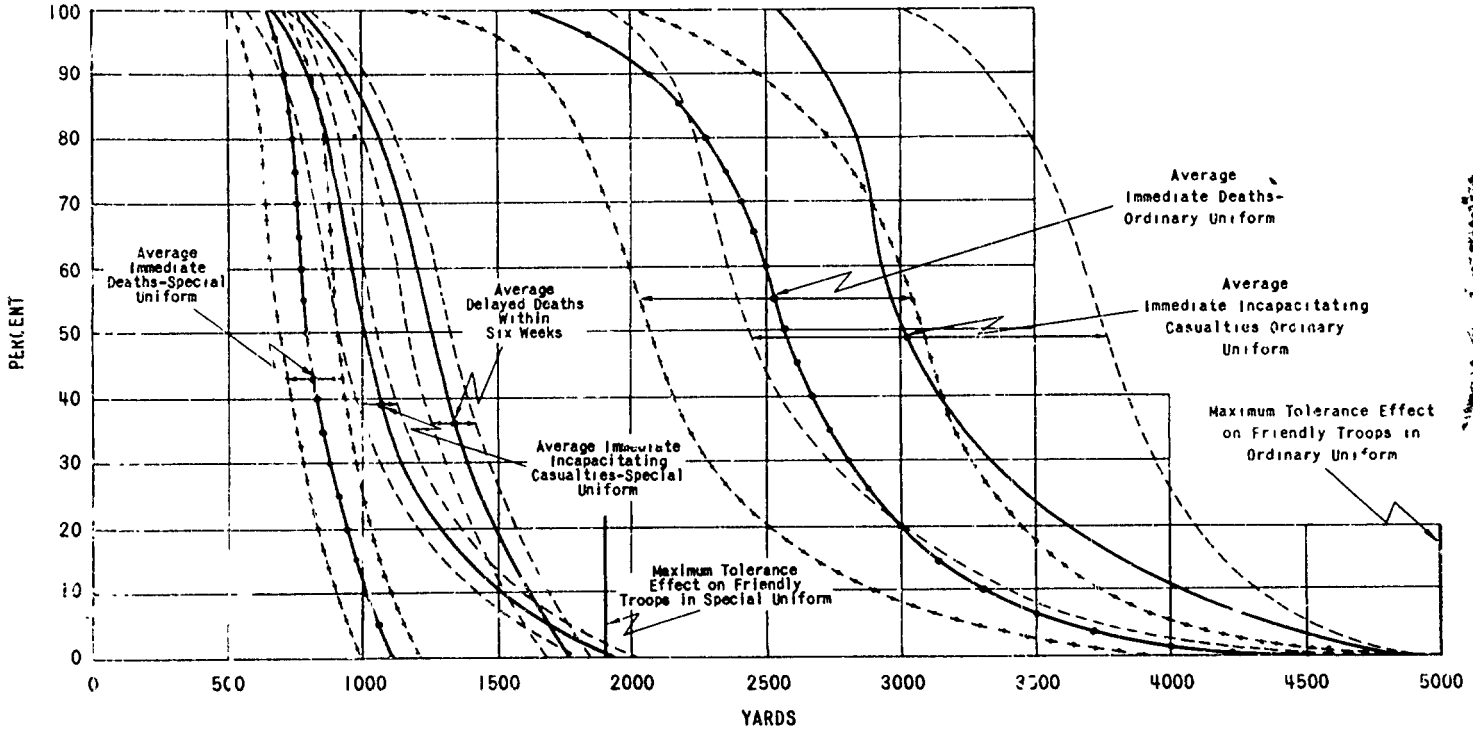

Figure 27.--Casualties Among Troops in the Open Exposed to a 20 KT Atomic Weapon Exploded in the Air at a Height of 600 Yards, on a Clear Day

(Note: In ordinary uniforms predominant cause of casualties is thermal radiation; in special uniforms it is gamma radiation; delayed deaths are principally those from gamma radiation)

0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
YARDS

Figure 27.--Casualties Among Troops in the Open Exposed to a 20 KT Atomic Weapon Exploded in the Air at a Height of 600 Yards, on a Clear Day

(Note: In ordinary uniforms predominant cause of casualties is thermal radiation; in special uniforms it is gamma radiation; delayed deaths are principally those from gamma radiation)

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ENCLOSURE D
THE ST. LO BREAKTHROUGH

by

W. B. Heinz

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Equally important is the fact that incapacitation of 25 percent of the artillery would very probably be enough to render the artillery support of the attack ineffective. In this situation General Montgomery had managed to bring up most of the 1st and 10th Armored Divisions of the X Corps disguised as trucks and they were massing opposite Miteiriya Ridge.

From Figures 25 and 27, it is estimated that within a radius of 2,550 yards there would be 100 percent incapacitating casualties. Five 20 KT bombs would be required to cover the same offensive position this way and would result in the incapacitation of 55,800 men, of whom at least 55 percent would be dead.

CONCLUSIONS

For the first situation, it is concluded that:

Three atomic bomb explosions appropriately placed would probably have prevented the British from executing an effective offensive, principally due to the serious loss to their artillery.

Five atomic bomb explosions suitably placed would incapacitate 100 percent of the 30th Corps and the fraction of the X Corps armored divisions employed opposite Miteiriya Ridge.

Considering some of the other British forces in the 13th Corps to the south, it can be seen that more than 50 percent of the 7th Armored Division would be incapacitated between 2,550 yards and 3,050 yards by an atomic bomb burst over the center of the dotted area using the point on the suitable curve giving 3,050 yards for 50 percent incapacitation. For the distance out to 2,550 yards from the zero point of the bomb there would be 100 percent incapacitation.

SECOND SITUATION

ASSUMPTIONS

The same assumptions are made as in the first situation with the exception that the British troops are equipped with special uniforms, to which both Figures 25 and 27 refer, and this implies that they have cognizance of atomic weapons and their possibilities tactically.

Under the assumptions of this situation it is seen from the curves for immediate incapacitating casualties, special uniforms, that within a radius of 1,400 yards from the zero point of an atomic burst more than 25 percent incapacitating casualties may be expected. Twelve atomic bombs spaced 1,000 yards apart would be sufficient to incapacitate more than 50 percent of the British forces from the 9th Australian. 51st Highland, 2nd New Zealand, 1st South African, and 4th Indian Divisions as situated. Ten 20-KT atomic bombs spaced 1,200 yards apart along the same line would result in more than 25 percent casualties, and would probably be sufficient to render the artillery ineffective.

CONCLUSIONS

Ten atomic bombs would probably be sufficient to prevent the offensive.

Twelve atomic bombs would be sufficient to incapacitate more than 50 percent of the men massed for attack.

THIRD SITUATION

After the British attacking troops had made the first penetration at the Miteiriya Ridge section, they had penetrated into a German position which is shown in Map 19. The development of the position of the 2nd New Zealand Division in these earlier days of the attack from 23 October to 27 October is shown in Map 20. This situation will be considered.

ASSUMPTIONS

The Axis had available air burst 20 KT bombs.

The British did not have knowledge of atomic weapons.

The British troops were in the open and in ordinary uniforms.

It is seen from Maps 19 and 20 that the salient at which the British planned to break through is about 3,000 yards wide at the Axis position of the line of antitank mines and mounted guns situated about 2,000 yards in front of Miteiriya Ridge. The Ridge is the line of contour of Map 19, at 30 meters above sea level. Early on 2–3 October at 2200 hours there were about 30,000 troops directly behind this salient in an area of 8 by 4 miles, and this concentration would be a good target for atomic weapons, for two atomic bursts of 20 KT in depth with a separation of 3 miles would incapacitate 100 percent of the troops out to a radius of 2,550 yards from each burst and

would incapacitate more than 50 percent of the troops between 2,550 and 3,050 yards. This means that of the 30,000 total troops an estimated 23.000 in this congested area would be incapacitated, and of the remaining 7,000 more than one-half incapacitated.

The next morning the 1st Armored Division of the X Corps was in this same area and taking its strength of 17,000 men or one-half the X Corps, there was a possibility of incapacitating the same estimated fraction, 88 percent of them or 15,000 more troops.

However, in order to counter an offensive concentration of this kind with atomic weapons, great care would have to be exercised since from the curves of deaths and casualties (Figures 25 and 27), it is noted that for friendly troops in the open in special uniform the maximum tolerance effect is at 1,900 yards from the zero point of the bomb, at 2,000 yards for friendly troops in fox holes in ordinary uniforms, and at 1,650 yards for friendly troops in special uniform in fox holes. So it is concluded that in most cases about 2,000 yards must be left between friendly troops and the zero of the bomb burst.

CONCLUSIONS

There was an instance of concentration at the breakthrough point in which the employment of a 20 KT atomic bomb placed suitably would have broken the strength of the attack.

The proximity of friendly troops in battle contact with the enemy would have made the decision to use atomic weapons very difficult, especially in view of the inaccuracies of whatever method of delivery was chosen.

FOURTH SITUATION

ASSUMPTIONS

The British forces had air burst atomic bombs.

The Axis forces did not have knowledge that atomic weapons would be used.

The Axis forces were in the actual defensive position shown in May 17, which, in view of the flat terrain and lack of trees, means that they were essentially in the open with respect to an air burst atomic bomb.

CONCLUSIONS

In this assumed situation it can be seen that using 2,550 yards for the radius of 100 percent incapacitation the employment of one 20 KT atomic bomb above Miteiriya Ridge at the center of the planned attack salient would have cleared a path 5,100 yards wide at the ridge and probably been sufficient to effect the breakthrough immediately thereafter since the defense was not in great depth, and the artillery personnel would have been more than 25 percent incapacitated out to a radius of 3,500 yards from the zero point.

To consolidate such a breakthrough it would probably be desirable to employ atomic weapons against the 15th and 12th Panzer Divisions assuming that they were deployed within the regions shown in Map 17. One 20 KT atomic bomb suitably placed over the 21st Panzer Division would incapacitate practically the entire division immediately and an estimated 75 percent of the 15th Panzer Division. This would mean about 23,000 of the armored personnel and would probably lead to rapid consolidation of the breakthrough with subsequent encirclement of the remaining Axis forces.

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ENCLOSURE D
THE ST. LO BREAKTHROUGH

by

W. B. Heinz

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THE ST. LO BREAKTHROUGH

INTRODUCTION

On 25 July 1944 the US First Army broke out of the hedge-row areas of Normandy, at the base of the Cotentin Peninsula, where progress had been so laboriously slow until then. The breakthrough was performed by the VII Corps, under the command of Lt Gen J. Lawton Collins, the scene being a 5-mile stretch of the St. Lo–Periers Highway just outside of town on the northwest side of St. Lo. Aside from the critical turn in historical events which it signalled, this breakthrough action was characterized principally by the concentration of US forces that were massed for the assault, and by the bombing attack which preceded their advance. In this carpet bombing operation the enemy troops were showered with what was perhaps the greatest concentration of bombs ever used in the history of tactical warfare.

As a test situation for exploring the tactical possibilities of atomic bombs, the St. Lo breakthrough afforded two conjectural opportunities for advantageous use of that weapon: an opportunity for the Germans to have used it against our massed forces; and an opportunity for us to have used 1 or more atomic bombs instead of the 5,000 tons of conventional bombs which actually were used in the carpet bombing. It was therefore selected as the subject of a scientific study, the extent and detail of which would depend upon the completeness in which essential facts were found in the record.

As the study progressed it became apparent that there exists too little detailed information about exact locations and strengths of military units on either side to support the elaborate analysis which would be necessary to make refined predictions of damage which would have been sustained from atomic-bomb attack. It has therefore been necessary to base estimates upon figures representing average concentrations of men and materiel within hypothetical bomb damage areas. Instead of being a basis for detailed analysis of expected damage from atomic attack upon ground forces, the St. Lo action has provided means for semi-quantitative estimates of damage and for logical, specific reasoning about types of military circumstances which will require future commanders to make difficult selections from their bags of weapons, including atomic varieties.

In estimating what would have happened if one side or the other had used atomic bombs, all problems involved in delivering that weapon singly, or in two or more coordinated drops have intentionally been by-passed. Deliverability considerations are so numerous and so complicated that they are considered to be outside the scope of the present study. Estimates of effects are therefore based upon the assumption that the stated numbers of bombs have in some manner been delivered upon the selected points.

This by-passing of deliverability problems is difficult to maintain, however, when the safety-withdrawal of friendly troops is being examined. The distance to which they must withdraw is unavoidably dependent upon bombing accuracy, and this depends upon the method of delivery which is to be used. Delivery by guided missile is another means which should be considered. Since accuracies to be expected are still unproven, it would be unprofitable to base withdrawal procedures upon this means for delivery. The best recourse is to use a nominal accuracy figure from strategic bombing experience and study, shaded a bit toward the low-error side to allow for the difference between strategic and tactical accuracies. As a round figure, a CPE (circular probable error) of [illegible],000 yards is reasonable.

A desirable withdrawal procedure would appear to rest upon the following criteria:

1. Withdrawal positions to be prepared, comprising fox holes or better protection for friendly troops.

2. Friendly troops to be warned of the impending use of each atomic bomb, with a time

accuracy in the order of one minute probable error, in order that they can utilize the available cover.

3. Minimum withdrawal distance for nearly zero probability of permanent injury to friendly personnel. The hazard which fixes the minimum withdrawal distance is Gamma radiation. The counterbalancing hazard which affects the maximum withdrawal distance is the time required to attack after atomic bombing preparation. Casualties in attack become much greater if too much time is allowed to pass between bombing and attack.[23]

4. It appears that a minimum distance of 1,600 yards from the projected center will be typical for air burst of a 20 KT bomb, the randomness of bombing requiring withdrawal beyond that distance by an amount which will depend upon the risk which each commander chooses to accept in return for greater safety in subsequent attack.

WHAT DID HAPPEN?

The breakthrough was performed by the US First Army, VII Corps, which had concentrated its 9th, 4th, and 30th Inf Div back of a 5-mile front extending from the Vire River westward along the St. Lo–Periers Highway. The 119th Inf Regt rested its left flank on the Vire River. Next in order were the 120th, the 39th, 47th, and 60th Inf Regt. Their formations extended back of the line for a distance ranging from 2 to 2½ miles. Thus, there were concentrated in a total area of 10 to 12 square miles some 28,000 troops, including both combat and service personnel and equipment. A list of typical equipment for 5 infantry regiments taken from FM 101-10 appears in Table XIX where average concentrations of men and various classes of equipment are given also.

The 5 leading infantry regiments were supported by the remaining forces associated with their divisions, backing them up as closely as space would permit. Thus, in a second zone, immediately back of that occupied by the leading 5 infantry regiments, there were also concentrated approximately 28,000 troops and their equipment, as listed in Table XX.

TABLE XIX
MEN AND EQUIPMENT FOR FIVE INFANTRY REGIMENTS PER FM 101-10

MEN AND EQUIPMENT	TOTALS FOR 5 INF REGTS	AVERAGE CONCENTRATION PER SQUARE MILE
Men	28,206	2,600
Tanks	216	20
Guns and Mortars	29,374	2,700
Rocket Launchers	846	77
Trucks, Tractors and Armored Cars	3,621	330
Ammunition *tons*	[1] 1,763	160
Electrical Equipment:		
Switchboards	84	8
Radio Sets	840	76
Meteorological Observation Sets	1	
Telephones	200	18
Power Units	117	11
Detector Sets	16	1.5
Floating Bridges	27	2

[1] Figure may be doubled when units are deployed for combat

With respect to artillery, the General Board reported[24] "On the division level there was what might be called a normal organization for combat for the division concerned." In addition, 7 more 105mm howitzer battalions were attached to the VII Corps, the 9th Inf and the 2nd and 3rd Armored Div getting 2 each, while the remaining 1 went to the 30th Inf.

Summarizing, the same report states: "In VII Corps, the penetrating force, there was an average of 5.67 light, 2.67 medium and 3 heavy battalions in position firing per division committed." The greatest weight of artillery was behind the 9th Div, where there were (not including the Corps general support battalions) 3.3 light and 1.0 medium battalions per infantry regiment.

"At the point of break-through by VII Corps the assault front was 6,000 yd which gave a density of 1 artillery piece, firing, per 14 yd of front."

It seems from the General Board report that the decision to use such heavy bombing prep-

[23] See Bibliography 6.

[24] See Bibliography 4

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aration resulted in part from a shortage of available artillery ammunition. The artillery did participate in the preparatory bombardment to considerable extent, the flanking VIII and XIX Corps cooperating with the VII Corps artillery in this effort.

It has been impossible to determine exactly how much artillery fire was added to the bomb tonnage dropped in the 2,500 by 6,000 yard target area during the period prior to the infantry attack. It is recorded that 3,072 tons of artillery projectiles were fired by the First Army during the 3 days commencing 25 July, the breakthrough day. Based also on partial figures for Corps artillery fire, it appears that approximately two-thirds of that total, or 2,000 tons was fired during the preparation.

THE GERMAN FORCES

A G-2 estimate of enemy strength facing the VII Corps on 17 July 1944 provided a figure of 8,000 men, with 35–40 tanks. Subsequently, in September 1945, discussions with Gen Fritz Bayerlein (CG, Pz Lehr Div) indicated that the actual number was close to 5,000 men when the US attack commenced on 25 July.

"Having failed to note the build-up of troops west of the Vire River, and with no premonitions of the coming air offensive, the enemy had taken no unusual precautions in the Marigny–St. Gilles area."[25]

Enemy works consisted "chiefly of road blocks, trenches, various temporary field artillery, machine gun and antiaircraft installations—supply dumps and vehicle bays."

Tables XXI and XXII summarize the best available information about the strength of the Panzer Lehr Division, which comprised the entire German force directly opposing the VII Corps breakthrough.[26]

TABLE XX
MEN AND EQUIPMENT FOR 2 ARMORED DIVISIONS AND 1 INFANTRY DIVISION PER FM 101-10

MEN AND EQUIPMENT	TOTALS FOR 2 ARMORED AND 1 INFANTRY DIVISION	APPROXIMATE AVERAGE CONCENTRATION PER SQUARE MILE
Men	50, 750	3, 000
Tanks	890	52
Guns and Mortars	54, 305	3, 200
Rocket Launchers	1, 946	115
Trucks, Tractors and Armored Cars	19, 668	1, 200
Ammunition *tons*	4, 389	260
Electrical Equipment:		
Switchboards	168	10
Radio Sets	1, 686	100
Meteorological Observation Sets	3	
Telephones	399	23
Power Units	234	14
Detector Sets	33	2
Floating Bridges	54	3

THE ACTION AS IT OCCURRED

Phase one of the breakthrough action was to start with "intense aerial bombardment by fighter bombers, medium, and heavy bombers, of an area approximately 2,500 yards deep and 6,000 yards wide. Also the area was to be subjected to heavy artillery fire." In carrying out this carpet bombing attack the 9th Tactical Air Command deposited 5,000 tons of bombs in that area, namely a space of 5 square miles. In addition to this, approximately 2,000 tons of shells were contributed by artillery bombardment. The average explosives concentration was therefore roughly 1,400–1,500 tons per square mile, or 1 pound per square yard.

Details of the bombing schedule are worth repetition.[27] "Bombardment of the selected target area prior to the attack was to be in accordance with the following plan:

"(1) Twenty minutes of bombardment by 350 fighter-bombers on a narrow strip along the Periers–St. Lo Road.

"(2) One hour of bombardment by approximately 1,500 heavy bombers on an area 2,500 yards deep and 6,000 yards wide on the front of the VII Corps.

"(3) Twenty minutes of bombardment, commencing at H Hour, by 350 fighter-bombers on the original narrow strip.

"(4) Bombardment from H plus 30 to H plus 75 minutes by 396 medium bombers on the southern half of the main bombing area.

"(5) Bombardment of bridges along the Vire and Sienne Rivers and their tributaries."

[25] See Bibliography 3.
[26] See Bibliography 7.
[27] See Bibliography 1.

TABLE XXI

ESTIMATED STRENGTH AND CASUALTIES OF PANZER LEHR DIVISION [1]

(24 to 25 July 1944)

UNIT	FULL STRENGTH		STRENGTH 24 JULY		LOSSES 24–25 JULY	
	Men	Armor	Men	Armor	Men	Armor
Panzer Regt	800	183 (x)	300	32 (x)	150	25 (x)
901 Pz Gr Regt	1,800	205 (a)	250	120 (a)	200	(y)
902 Pz Gr Regt	1,800	205 (a)	300	130 (a)	250	(y)
Artillery	1,200	42 (b)	800	23 (b)	200	12 (b)
TD Bn.	220	31 (c)	120	12 (c)	70	10 (c)
TD Ren Bn	500	88 (d)	100	60 (d)		(e)
Engr Bn	450		120			(f)
AA Bn	350	12 (b)	220	8 (b)	80	5 (b)
14 Para Regt		.	500		350	
Ct Heintz	..	.	450	.	400	
Bn, 985 Inf	.	.	600	..	400	
21cm Mortar Bn	.	...	130	4 (b)	50	..
Totals	7,120	766	3,890	389	2,150	52

(x) Tanks
(a) Self-propelled weapons
(b) Guns
(c) Tank destroyers
(d) Armored vehicles
(e) The Entire Ren Bn was near Percy for reorganization
(f) On 24 July division reserve near Carantilly
(y) No estimate

Note. Gen. Fritz Bayerlein, CG of Panzer Lehr Division, made these estimates in September 1945. He explains that all figures should be prefaced with the qualification "about", but that he was particularly well-informed about the strength of his units for a number of reasons: He had to sign and adjust daily strength reports after personal investigation, he remembered these figures better because he always used them as a basis for pleading for reinforcements; and as recently as May 1945 he used a notebook containing the exact daily personnel strength figures. See Gen Bayerlein's memorandum this subject, 9 October 1945

[1] See Bibliography 3.

TABLE XXII

VII CORPS G-2 ESTIMATE OF TOTAL ENEMY TROOPS, 20 JULY 1944, COMPARED WITH GEN. FRITZ BAYERLEIN'S CORRECTIONS FOURTEEN MONTHS AFTERWARDS

VII CORPS G-2 ESTIMATE		CG. PZ LEHR DIV ESTIMATE	CG. PZ LEHR DIV COMMENTS
5 Para Division:			
Co, 12 Ren Bn	150		Were actually under 2 SS Pz Division
13 Para Regt.	1,500		
1 Bn, 14 Para Regt	500	500	
3 Bn, 14 Para Regt	500	500	
11 Para Ren Bn	300		10 July removed to 11 Para Corps
Panzer Lehr Divisio			
130 Engr Bn	300	120	Three Bns. not one
130 Arty Bn	200	800	
4 Co. 130 Pz Ren	100	100	Should be 3 and 4 Companies
901 Pz Gren Regt	700	300*	
902 Pz Gren Regt	700	350*	
2 SS Pz Div:			
SS Engr Bn	400		On 20 Jul rejoined 2 SS Pz Division
3 Bn SS Deutschland	200		
3 Para Division:			
1 Co, 5 Para Regt	200		Not in front lines of Pz Lehr Division
265 Inf Division.			
2 Bn, 894 Regt.	300	**	
Total	6,050		

Note By CG, Panzer Lehr Division Additional troops in this sector on the east flank, were Combat Team Heinz (275 Inf Div), consisting of about 500 men, and an Army Engineer School, consisting of about 100 men

* About.

** Not known.

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As a result of this bombing and artillery fire the German forces suffered approximately 1,000 casualties, or 20 percent, an estimate based on recollections of Gen Fritz Bayerlein. The reliability of this figure is subject to considerable question, the error probably being on the high side.

The US 4th, 9th, and 30th Inf Regt sustained 1,003 casualties [28] on the breakthrough day. If we assume that there were 4,000–5,000 defenders at the beginning of the infantry advance, these casualties represent an average of 0.25–0.2 casualties per defender.

Interpreted in terms of the analysis of reference [29] (OEG 385), this casualty level would have been predicted after bombardment by 0.3 lb per yd^2 equivalent 5-inch AAC (antiaircraft common) shell, totalling 2,300 tons, as compared with 5,000 tons of bombs and 2,000 tons of mixed artillery shells which were actually used. This fact suggests that bombing may create a neutralizing effect per ton which is lower than that of artillery bombardment, and by a factor which may be in the order of 3.

To quote further from the *Report of Operations, 1st US Army* [30] "On 25 July the weather was clear and the operation was ordered. The front line troops withdrew 1,200 yards to the north of the forward edge of the target area and at 0940 hours, fighter-bombers commenced striking the initial 300-yard strip along the Periers–St. Lo Road. Immediately following the fighter-bombers the heavy and medium bombers attacked the breakthrough area as scheduled. At 1100 hours the infantry moved forward.

"The enemy gave ground in front of the 4th and 9th Divisions after his light and medium artillery had been silenced. Prisoners of war stated that our carpet bombing was devastating. The enemy troops who were not casualties were stunned and dazed. Weapons not destroyed had to be dug out of the dirt and craters, and cleaned before they could be used. Communications were almost completely severed. Other units, apparently less affected by the bombardment, offered moderate to stubborn resistance, employing automatic weapons which were found to be well emplaced.

"Resistance decreased after the forward enemy positions had been taken, and the line by the end of the day had moved forward almost 2 miles. The enemy's position was definitely broken."

What would have happened if the Germans had unexpectedly dropped atomic bombs upon US forces?

Conditions were particularly favorable to use of atomic bombs for defense by the Germans, not only because of the high concentration of opposing US forces, but also because there was a strong predictable south wind to carry fission products away from the Germans and deep into territory occupied by US forces. The military damage created by such fission products from an air burst might actually have been negligible; but the south wind would at least have lent considerable psychological stimulus to use of the bomb by the Germans.

The Germans would no doubt have considered the use of a subsurface burst in the soil beneath the Vire River, as a means of utilizing the favorable wind to best advantage. It would have carried radioactive water and soil deep into US territory. However, since insufficient data are as yet available for analysis of damage which might have been done by a subsurface burst, that problem will have to be the subject for a future study. Consequently the following estimates are based solely upon the effects of 20 KT bombs dropped for air burst at an altitude of 1,800 feet.

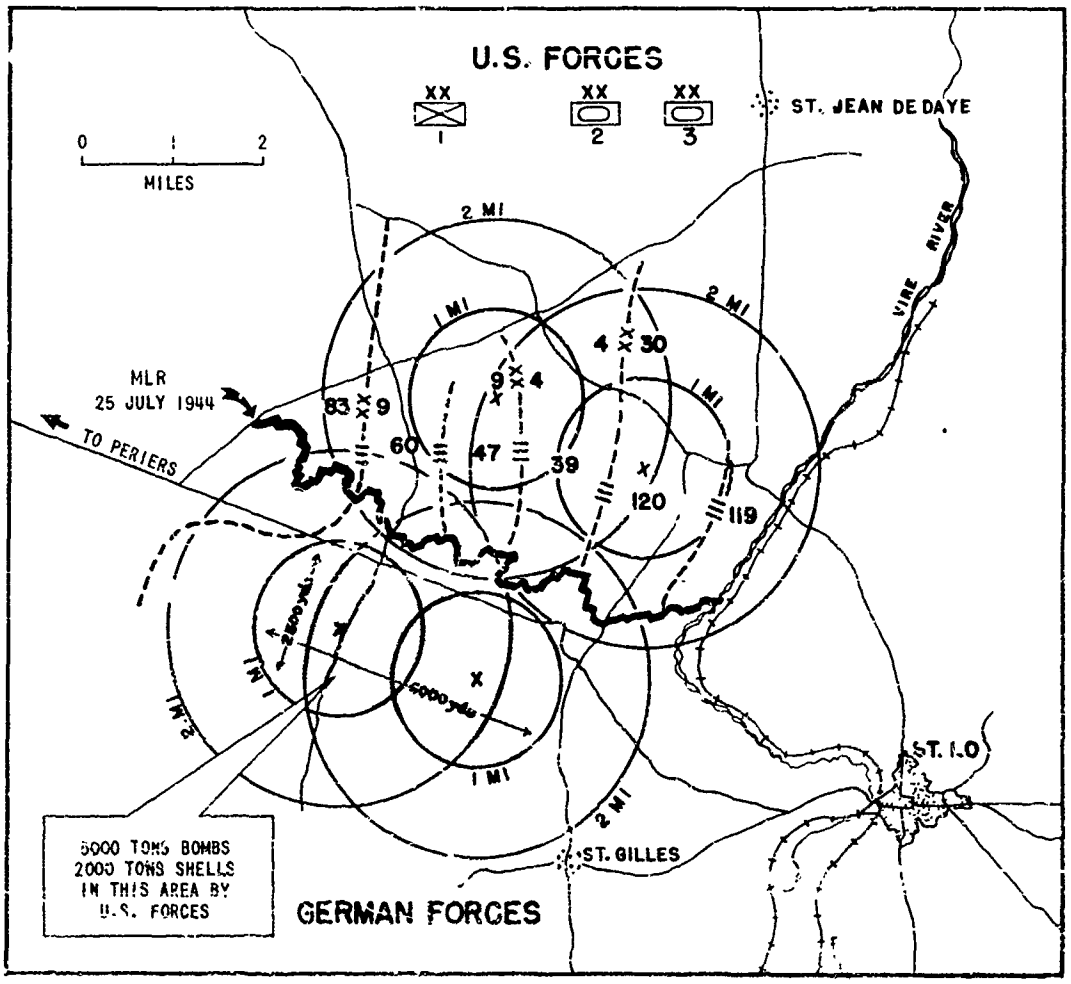
Six US divisions, plus seven attached artillery battalions, were concentrated as closely as possible behind a front only 8,000 yards wide, in contrast to typical SOP deployment of 1 division along a front of 5,000 yards. Three infantry divisions held the leading positions, while 1 infantry and 2 armored divisions were bivouaced immediately behind them. In view of this extreme concentration throughout the limited total area, it is assumed that the distribution of forces was fairly uniform. No part of the space would have been allowed to remain more thinly occupied than necessary. Exact locations of

[28] See Bibliography 2.
[29] See Bibliography 6.
[30] See Bibliography 7

the smaller units (individual battalions, et cetera) were not found in the record, and it has thus been necessary to use average numbers of men and equipment per square mile as the basis for judging probable damage.

Quantitative estimates of damage have also been restricted to personnel, since insufficient data about atomic bomb damage to military equipment are available for a realistic attempt to evaluate those losses.

On Map 21 circles have been drawn of 1-mile and 2-mile radii indicating the coverage which would have been achieved by 20 KT atomic bombs detonated at an altitude of 1,800 feet. The areas of major damage, i.e., within 2 1-mile radius circles, totals 6 square miles out of the 10–12 square mile territory occupied by the front-line divisions. Thus, 15,000 to 16,000 men and their equipment would have been within that intensely damaged area. Ninety to one hundred percent of those directly exposed to the flash, namely 13,000 to 16,000 men, would have been killed immediately if there had been no protection whatsoever. Since the US forces were not dug in to great extent, and since protection from flash afforded by trees would largely have been offset by damage from flying branches, it seems



Map 21.—The St. Lo Break-through, Normandy, 25 July 1944

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Use [redacted] eguards

probable that immediate deaths would actually have been of that order of numbers.

All the rest of the area occupied by the leading 3 US divisions lies within the 2-mile radius circles, wherein many casualties would have occurred from burns and a major psychological effect would have been created, particularly during a time early in the history of atomic attack.

In view of the critical importance of skilled personnel and of relatively vulnerable communication and automatic fire control equipment in effective US artillery fire, it is assumed that damage to artillery units represented by 25 percent immediate casualties would stop their fire for a long time. On this basis it appears that all of the artillery installations within the 2-mile radius circles, namely, nearly all those of the 9th, 4th, and 30th Div, would have been put out of commission by 2 atomic bombs for a period long enough for relatively weak German forces to have occupied [31] the bombed territory except for the US reserve divisions.

These divisions, the 1st, 2nd, and 3rd, would have been but little injured. They would have remained operational, and capable of strong action against enemy movement across the bombed area. Two more atomic bombs, however, would have immobilized those division, also, principally because of damage to personnel.

What would have happened if the US had unexpectedly dropped atomic bombs upon the Germans?

Had atomic bombs then been available the US might have used that weapon instead of the concentration of conventional bombs which preceded their infantry attack.

Damage comparisons show that two atomic bombs would have done several times as much damage to German personnel as they sustained from the conventional bombing, heavy as it was. A computation of casualties was performed upon the basis of personnel damage estimates which are presented elsewhere in this Appendix. These figures, applied to the geometry of 2 20 KT atomic bombs with optimum placing on the 2,500 by 6,000 yard target area, give the following casualty figures for a 5,000-man force evenly distributed:

Men in Ordinary Uniforms, Fully Exposed:

Immediate deaths	4,650
Incapacitated after ½ hr	350
Ramaining effectives	0

Men in Ordinary Uniforms, in Fox Holes:

Immediate deaths	560
Incapacitated after ½ hr	2,900
Remaining effectives	1,540

Depending upon the extent to which the Germans were under cover, their actual casualties would have been less than the first set of figures and greater than the second.

These figures should be compared with a figure of approximately 1,000 total casualties which the Germans suffered from the actual bombing. The number of deaths was not separately recorded. They thus had about 4,000 effectives ready to oppose the US infantry, who suffered 1,003 casualties in the leading three divisions. US casualties should have been negligible had atomic bombs been used.

CONCLUSIONS

The following conclusions omit all consideration of deliverability problems associated with tactical atomic bombing, which problems are outside the scope of the present study. It is assumed that by some means not described, the bombs could have been delivered upon the stated points.

1. With 2 correctly placed atomic bombs the Germans could have substantially destroyed the 3 US infantry divisions which spearheaded the US attack. They could probably not have occupied all of the bombed area with their relatively weak forces, however, unless they had also disposed of the 3 additional divisions which the US held in immediate reserve

2. Two more atomic bombs could have destroyed the effectiveness of the 3 reserve divisions behind the US front.

3. Two atomic bombs correctly placed by US troops would have gained substantially the same objectives which were actually gained by

[31] Considerations affecting the promptness with which atomic-bombed areas can be entered, and precautions which must be exercised, are described in the next section of this Enclosure, *Contamination and Decontamination of Atomic Bombed Areas.*

using approximately 5,000 tons of conventional bombs plus 2,000 tons of mixed artillery shells.

4. German casualties from 2 atomic bombs would have been at least 3 times what they actually were. US casualties caused by the Germans during the initial US infantry advance would have been reduced nearly to zero by atomic preparation, whereas those casualties actually totalled 1,003.

CONTAMINATION AND DECONTAMINATION OF ATOMIC BOMBED AREAS

The following information has been extracted from *Radioactive Contamination* by Edward S. Gilfillan, Jr. (ORO Technical Memorandum 14).

AIRBORNE CONTAMINATION

"Some radioactivity from every military atomic explosion will be carried off by the winds to contaminate other areas. The amount will vary from less than 1 percent from deeply buried or submerged explosions to more than 99 percent from bursts at altitudes exceeding 500 feet. Some of this will be so thoroughly mixed with the bulk of the atmosphere as to contribute only to world-wide contamination, and some will be deposited to contaminate well defined local areas, determined by weather conditions at the time of the explosion. For details, the reader is referred to the chapter on meteorology. A canyon 20 miles from the site of the Alamogordo test was contaminated to a radiation level of 40 roentgens per hour at the end of the first hour, and rain squalls brought down sufficient radioactivity from the Sandstone test to bring the radiation level to 90 roentgens per hour on islands hundreds of miles from Eniwetok. Such airborne contamination will be at worst an inconvenience; it will never be enough to deny passage through an area, or to suggest suspension of operations in the area for more than a few days.

SURFACE CONTAMINATION FROM AN AIR BURST

"Local surface contamination by fission products from air bursts at altitudes exceeding 500 feet is expected to be negligible compared with the radioactivity induced in surface materials by neutrons escaping from the bomb. At Bikini, the induced activity from the air burst at an altitude of 600 feet was approximately 20 roentgens per hour at the end of the first hour. This activity was largely due to sodium in the water and would have been much less if the explosion had occurred over average soil. At Nagasaki where the altitude was 1,800 feet it was completely negligible within a minute after the explosion. In this case only 0.025 percent of the fission fragments were left on the ground.

"Local contamination by fission products from bursts at altitudes less than 500 feet may be sufficient to affect ground operations, but not the use of harbors. The approximate radiation level in roentgens per hour on the ground at Alamogordo one hour after the explosion is given in Table XXIII.

"Assuming that the radiation level at any point varies inversely as the time, it can be shown by graphical integration of the figures in Table XXIII that a man willing to accept 30 roentgens would have to wait 15 minutes before crossing the area in a vehicle at 40 miles per hour. It would be six hours before he could walk directly across the contaminated area with the same exposure.

"How much the area would be contaminated by a burst on the surface of the ground is unknown. It seems probable that the radiation level within the crater would be very high, and outside the lip of the crater about the same as at Alamogordo. Surface material would be bull-dozed into the crater and the whole area covered at the new surface to tolerable levels. Restoration of communications disturbed by a surface burst would not be greatly hampered by radiation.

REOCCUPYING ATOMIC BOMBED AREAS

"Occupation forces entering an atomic bombed area, whether associated with the sender or receiver of the bomb, will be led a few hours after the attack by personnel equipped with radiological survey instruments for mapping the boundaries of those areas which should not be entered until later. Thereafter, or even before this if every man has been issued a fountain pen size electroscope, all services can proceed with their duties insofar as combat conditions will permit. However, it will be necessary to establish systematic procedures for frequent replacements of their personnel, the safe time for continuous occupation of a given place by each man depending upon the intensity of radiation there. Replacement schedules should be based upon the findings of quantitative measuring instruments.

CONTAMINATION OF WATER AND FOOD SUPPLIES

"Although the calculation is difficult and uncertain, it appears probable that even a direct hit by one atomic bomb on the reservoir supplying a large city will not render the water unfit to drink for more than one day. Dilution and absorption on the mud and filters combine to reduce dissolved radioactivity below harmful levels. If the explosion is on the watershed rather than in the reservoir it may be considered certain that the water will be safe.

Military units relying upon standard water treating equipment should have no serious problem from radioactivity in drinking water.

RESTRICTED [redacted]
Atomic [redacted]
Specific [redacted] Required
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TABLE XXIII
RADIATION LEVEL ON THE GROUND AT ALAMOGORDO ONE HOUR AFTER THE EXPLOSION

DISTANCE FROM ZERO-POINT YD	RADIATION, ROENTGENS PER HOUR
0	8,000
100	5,000
200	600
300	150
400	30
500	10
750	5
1,000	0.3
1,250	0.07

During the first few days, "water showing .002 roentgen per hour or less, as measured with an ionization chamber over a large body of water, can be drunk without hesitation," and the writer (Gilfillan) "would drink water showing .02 roentgen per hour rather than suffer from thirst."

However, a hazard develops from the gradual accumulation of radio-active iodine from decay of tellurium 131, one of the original fission products. By the twelfth day dangerous quantities may have been created and the external radiation from the water will have decreased so much that the ionization chamber test will no longer guarantee potability of the water, since it does not disclose the presence of radioactive iodine. This iodine itself will have decayed by 30 days to such an extent as to be no longer the principal menace, and the controlling factor will have to become the radiostrontium in the water.

It seems evident that military units operating in areas subject to hazard from underwater or underground atomic bursts will have to be equipped with scientific apparatus and suitably trained personnel to guarantee the safety of drinking water. Such facilities being available, however, it appears that the drinking water supply should not be a serious military problem, insofar as radioactive contamination is concerned.

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[redacted]

ENCLOSURE E

ATOMIC WEAPONS EFFECT ANALYSIS ON THE GERMAN ARMY AT THE VOLKHOV FRONT

by

Kathryn Bartimo, Dorothy K. Clark
Nicholas M. Smith

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Near-Drop Versus Far-Drop	127
Atomic Weapon Operation Against Front Line Troops	128
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[redacted]

[redacted]

M.G. Btl.

67 ARMEE

Pz Jg u Art
Lehr Rgt. 596
(Armored A.T. & Lt.
Arty. Regt.)

Reserves
86 Div.

91 MG
Btl.
(Machine Gun Bn.)

67

Reserves
268 Div.
45 Div.
56 Div.
86 Pz. Btl

II
Sch Br.
(Rifle Brigade)

NEVA RIVER

Rdf. Abt.

I./4

II/4

401

II/391

I./240

#Gorodok

391 III/391

I./391

I/399

Dubrow

III/399

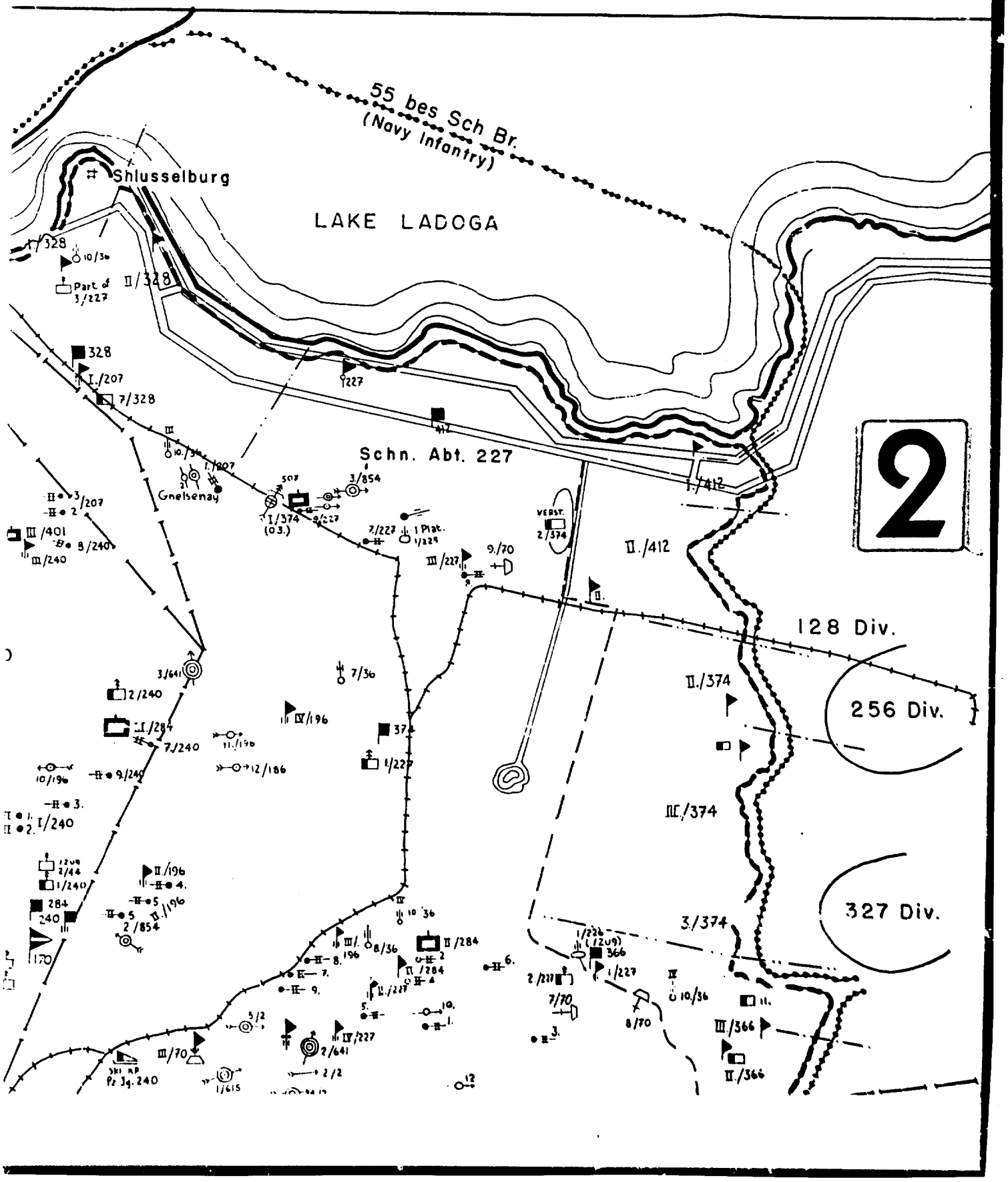
399

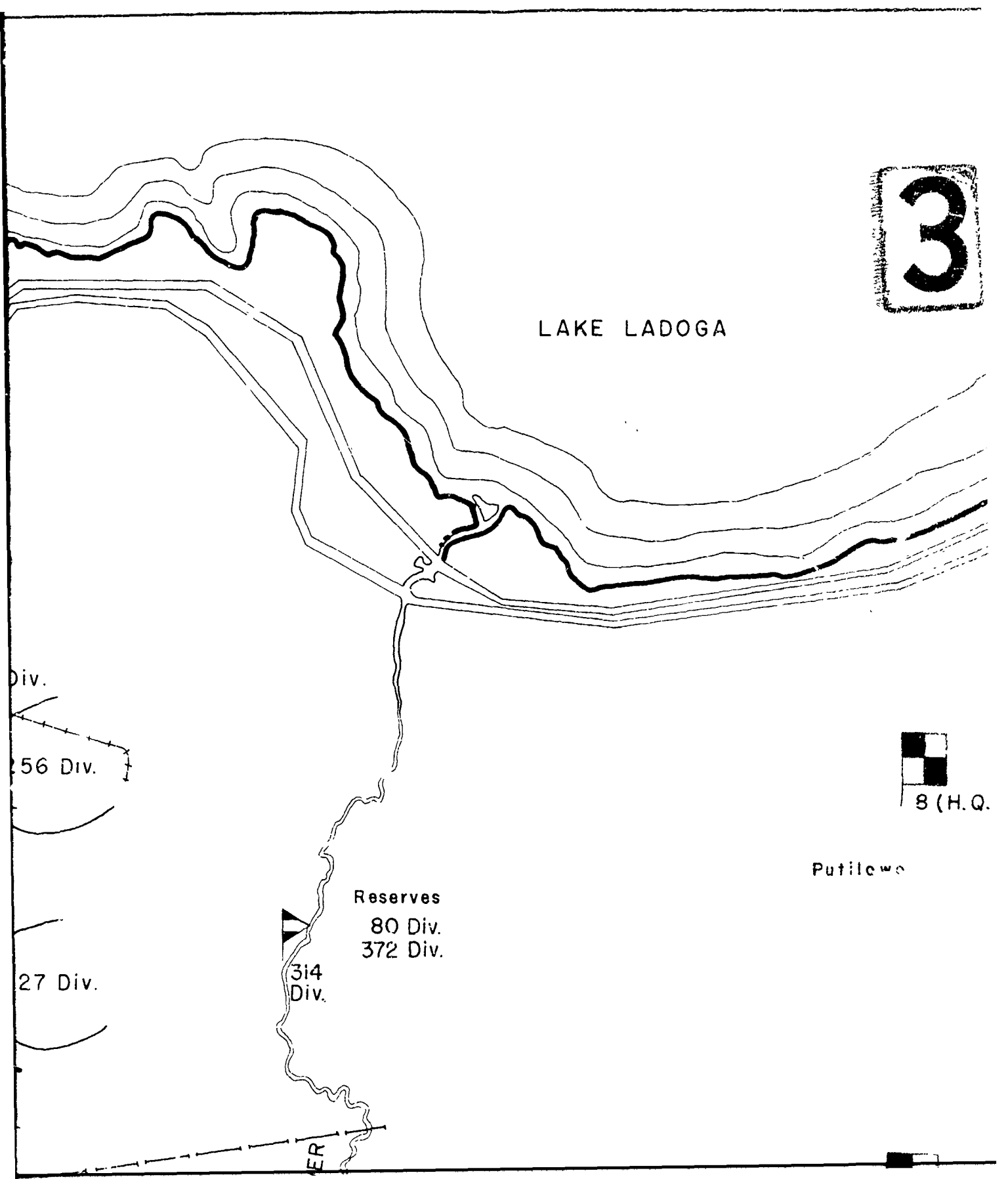
II/399

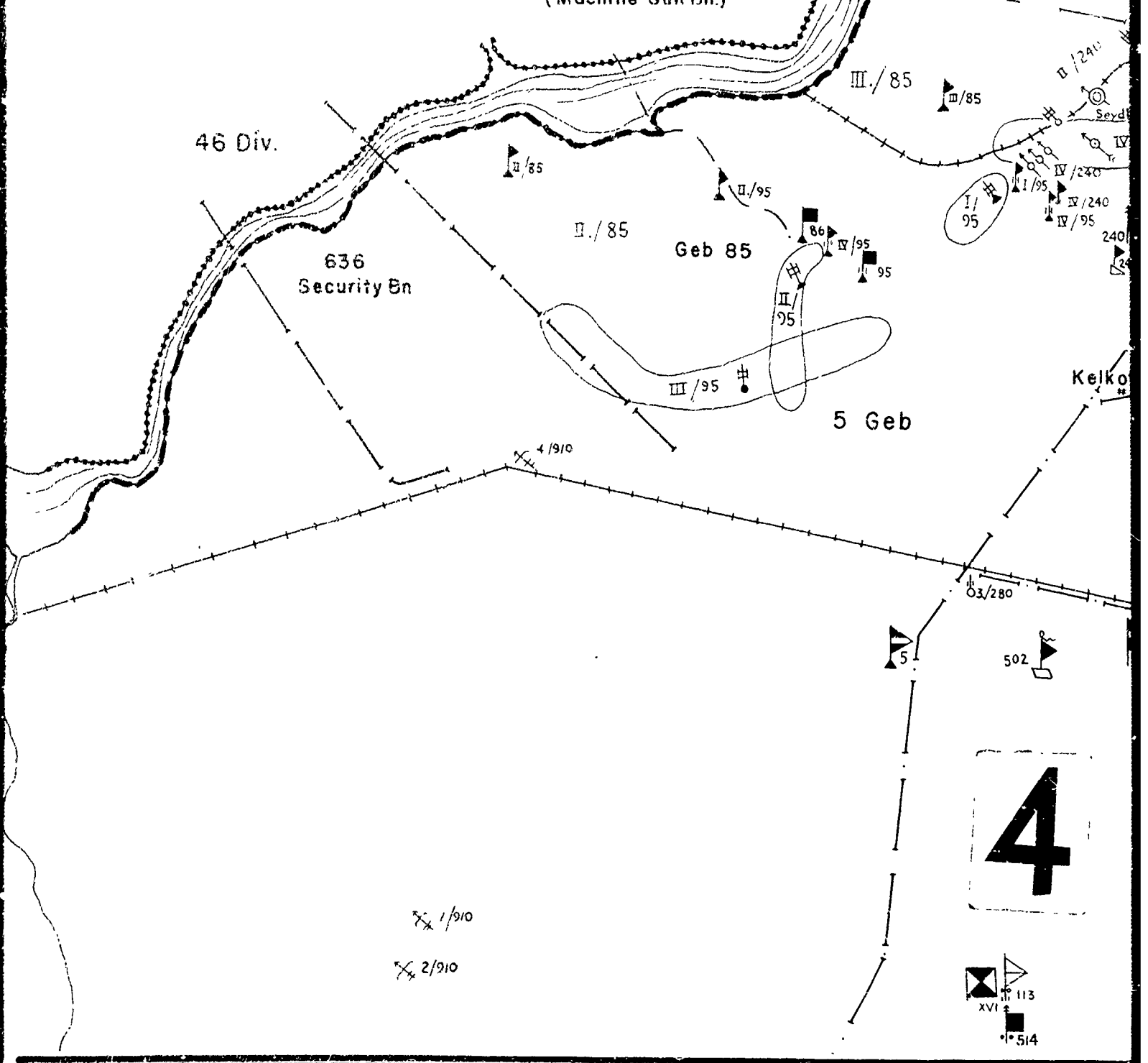
II/240

M.G. Btl. 93
(Machine Gun Bn.)

1

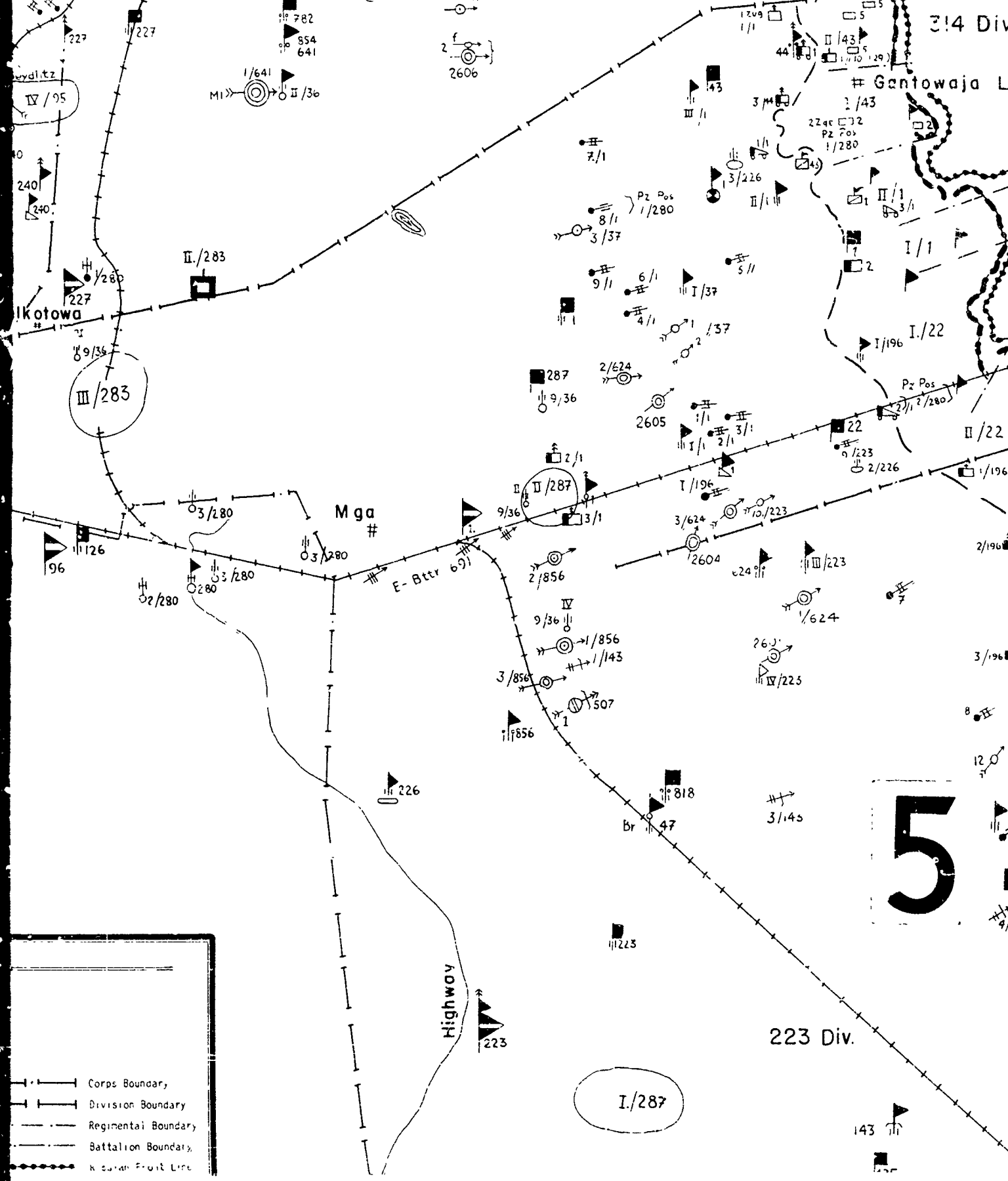

55 bes Sch Br.
(Navy Infantry)
Shlusselburg
LAKE LADOGA
Schn. Abt. 227
128 Div.
256 Div.
327 Div.
2

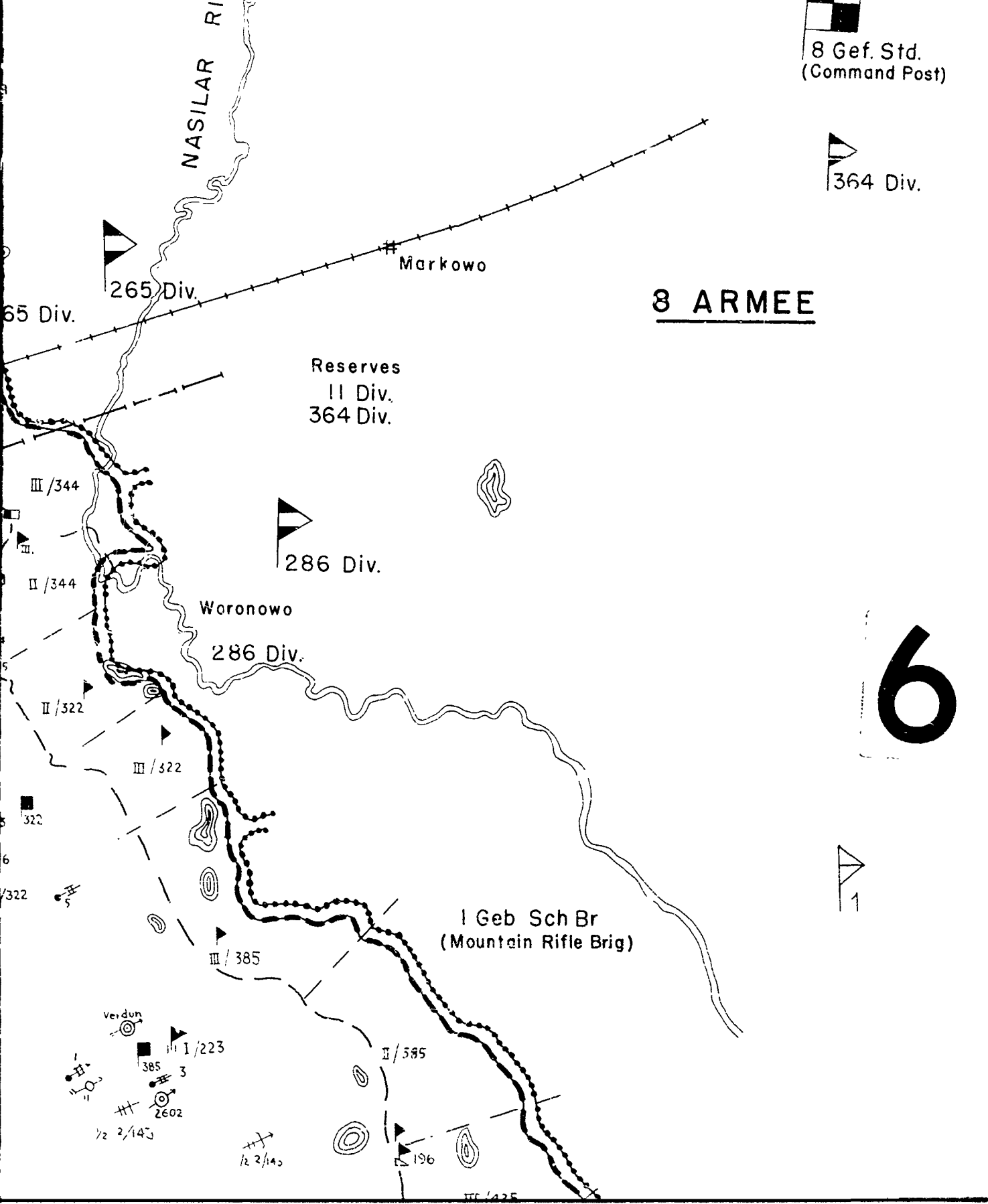

3
LAKE LADOGA
Div.
56 Div.
27 Div.
8 (H.Q.
Putilowo
Reserves
80 Div.
372 Div.
314
Div.
ER

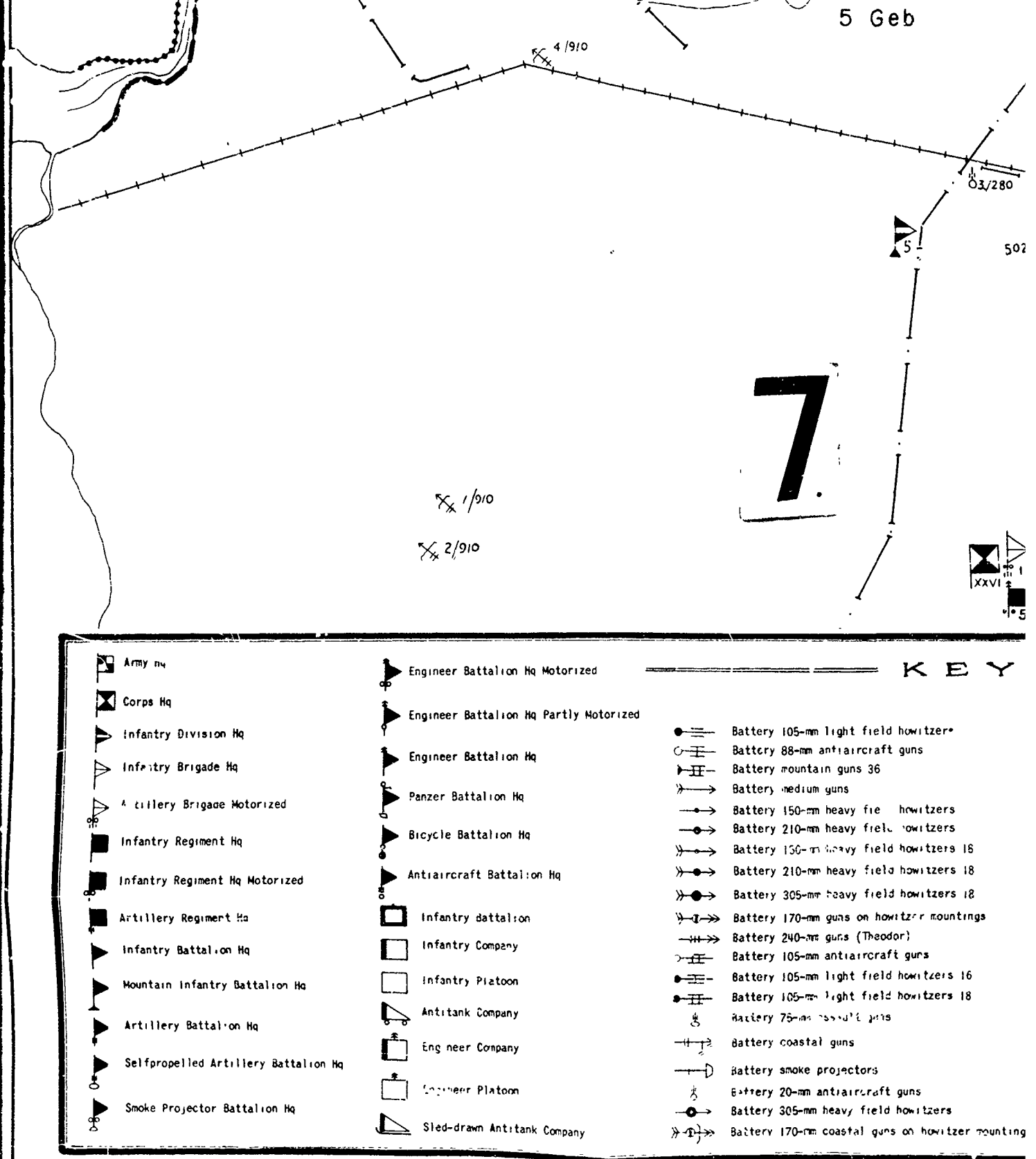


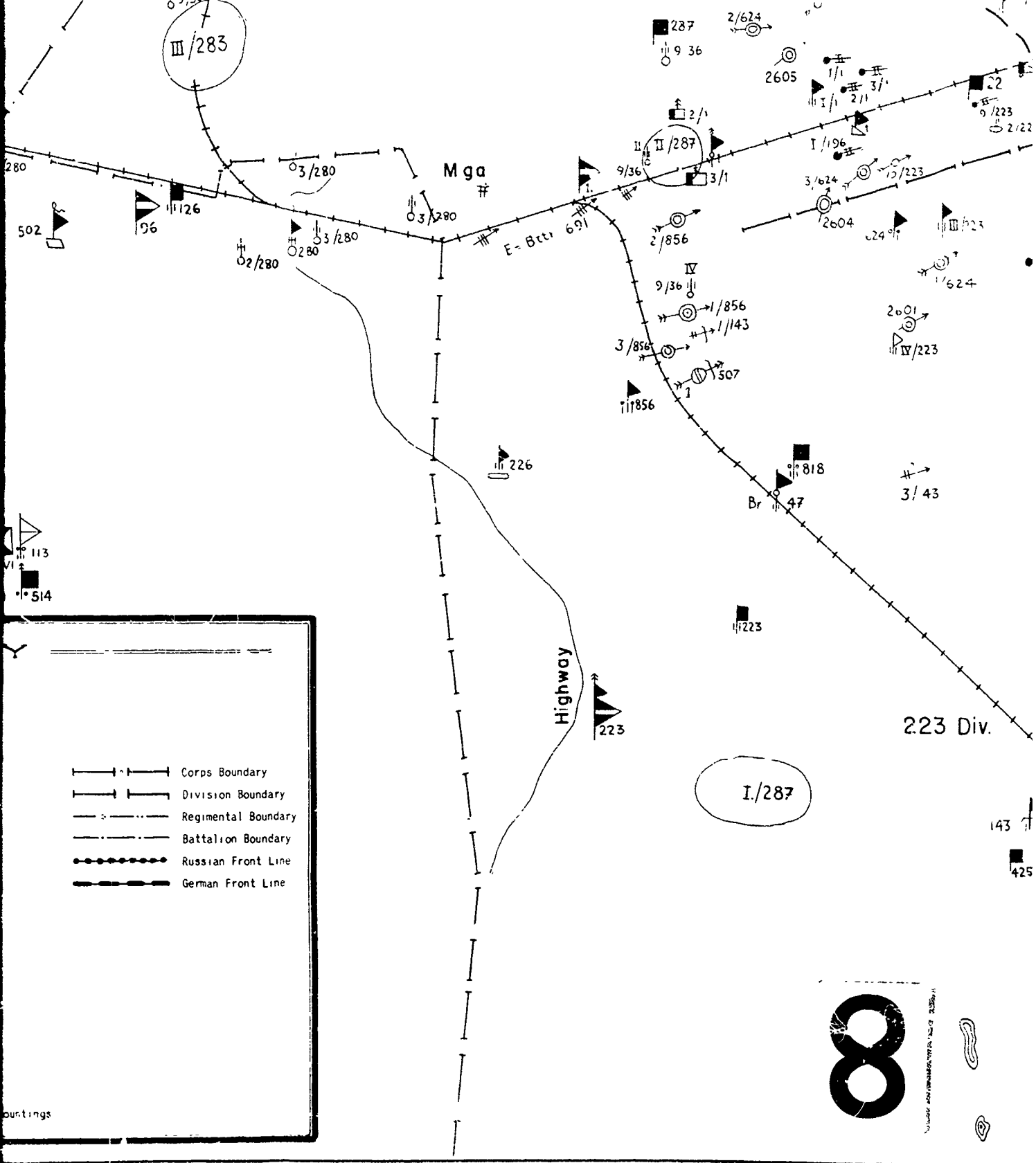
KEY

- Army Hq
- Corps Hq
- Infantry Division Hq
- Infantry Brigade Hq
- Artillery Brigade Motorized
- Infantry Regiment Hq
- Infantry Regiment Hq Motorized
- Engineer Battalion Hq Motorized
- Engineer Battalion Hq Partly Motorized
- Engineer Battalion Hq
- Panzer Battalion Hq
- Bicycle Battalion Hq
- Antiaircraft Battalion Hq
- Battery 105-mm light field howitzers
- Battery 88-mm antiaircraft guns
- Battery mountain guns 36
- Battery medium guns
- Battery 150-mm heavy field howitzers
- Battery 210-mm heavy field howitzers
- Battery 150-mm heavy field howitzers 18
- Battery 210-mm heavy field howitzers 18

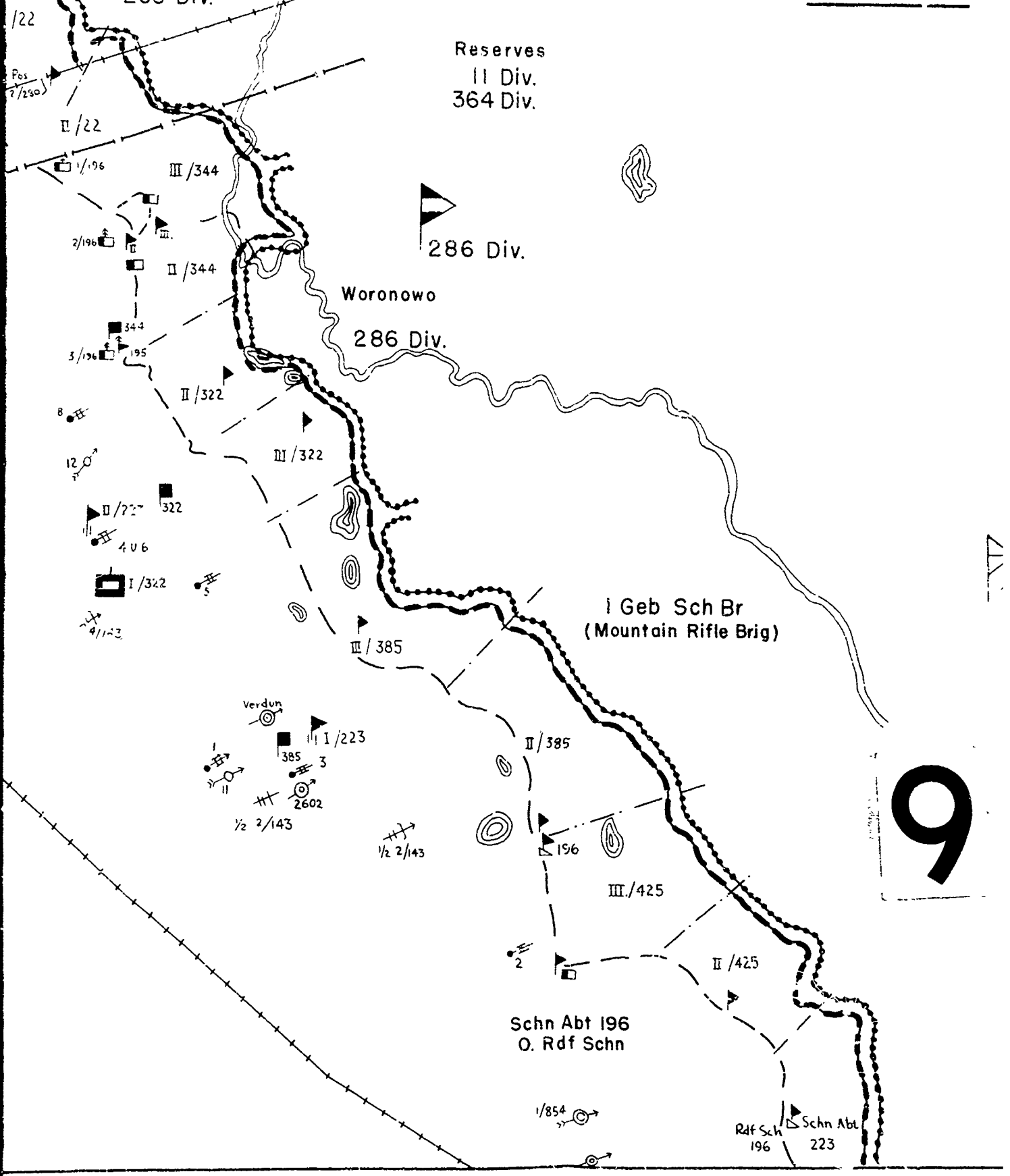

Mga
Highway
223 Div.
Corps Boundary
Division Boundary
Regimental Boundary
Battalion Boundary


NASILAR RI
8 Gef. Std.
(Command Post)
364 Div.
Markowo
265 Div.
65 Div.
8 ARMEE
Reserves
11 Div.
364 Div.
III/344
286 Div.
II/344
Woronowo
286 Div.
6
II/322
III/322
322
322
1
I Geb Sch Br
(Mountain Rifle Brig)
III/385
Verdun
I/223
385
3
2602
II/385
196


5 Geb
4/910
3/280
502
7
1/910
2/910
XXVI
KEY
Army Hq
Corps Hq
Infantry Division Hq
Infantry Brigade Hq
Artillery Brigade Motorized
Infantry Regiment Hq
Infantry Regiment Hq Motorized
Artillery Regiment Hq
Infantry Battalion Hq
Mountain Infantry Battalion Hq
Artillery Battalion Hq
Selfpropelled Artillery Battalion Hq
Smoke Projector Battalion Hq
Engineer Battalion Hq Motorized
Engineer Battalion Hq Partly Motorized
Engineer Battalion Hq
Panzer Battalion Hq
Bicycle Battalion Hq
Antiaircraft Battalion Hq
Infantry Battalion
Infantry Company
Infantry Platoon
Antitank Company
Engineer Company
Engineer Platoon
Sled-drawn Antitank Company
Battery 105-mm light field howitzers
Battery 88-mm antiaircraft guns
Battery mountain guns 36
Battery medium guns
Battery 150-mm heavy field howitzers
Battery 210-mm heavy field howitzers
Battery 150-mm heavy field howitzers 18
Battery 210-mm heavy field howitzers 18
Battery 305-mm heavy field howitzers 18
Battery 170-mm guns on howitzer mountings
Battery 240-mm guns (Theodor)
Battery 105-mm antiaircraft guns
Battery 105-mm light field howitzers 16
Battery 105-mm light field howitzers 18
Battery 75-mm assault guns
Battery coastal guns
Battery smoke projectors
Battery 20-mm antiaircraft guns
Battery 305-mm heavy field howitzers
Battery 170-mm coastal guns on howitzer mounting



Map 22—Situation 11 January 1943, Evening Before Soviet Attack


Reserves
11 Div.
364 Div.
286 Div.
Woronowo
286 Div.
I Geb Sch Br
(Mountain Rifle Brig)
Schn Abt 196
O. Rdf Schn
Rdf Sch 196
Schn Abt 223
Verdun
9

SECRET

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Atomic Energy Act - 1946
Specific Reprint[illegible]ance Not Requ
Use Military Classification Safeguards

RUSSIAN 67th ARMY
12 JAN 1943

Reserve Units

DIVISIONS:
123 rd

BRIGADES
11 th Inf
102 nd Inf
123 rd Inf
138 th Inf
142 nd Naval Inf
34 th Ski

BATTALIONS
74 th Mach. Gun
91 st Mach Gun

152 nd Armored Brig

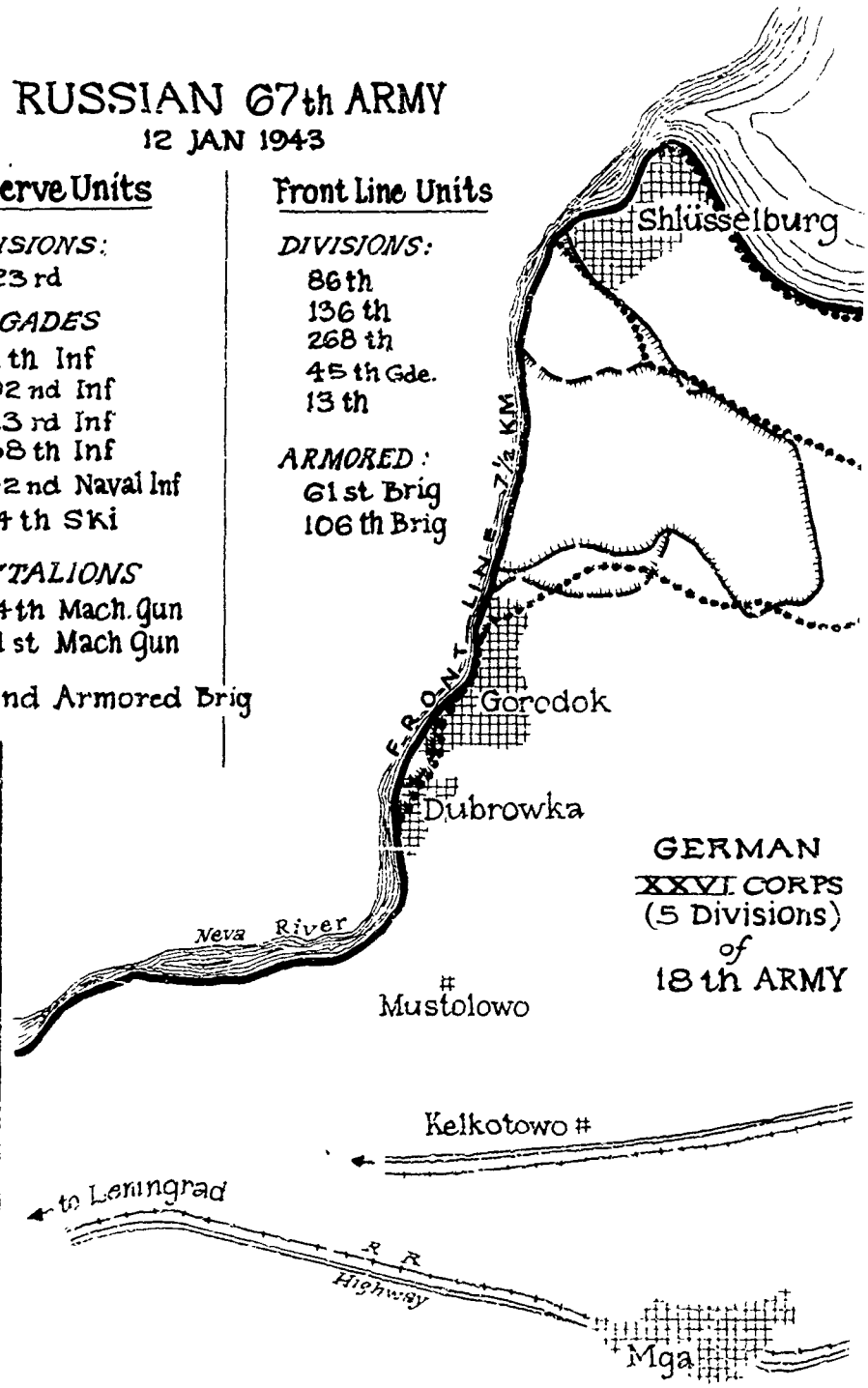
Front Line Units

DIVISIONS:
86 th
136 th
268 th
45 th Gde.
13 th

ARMORED:
61 st Brig
106 th Brig

Artillery Batteries

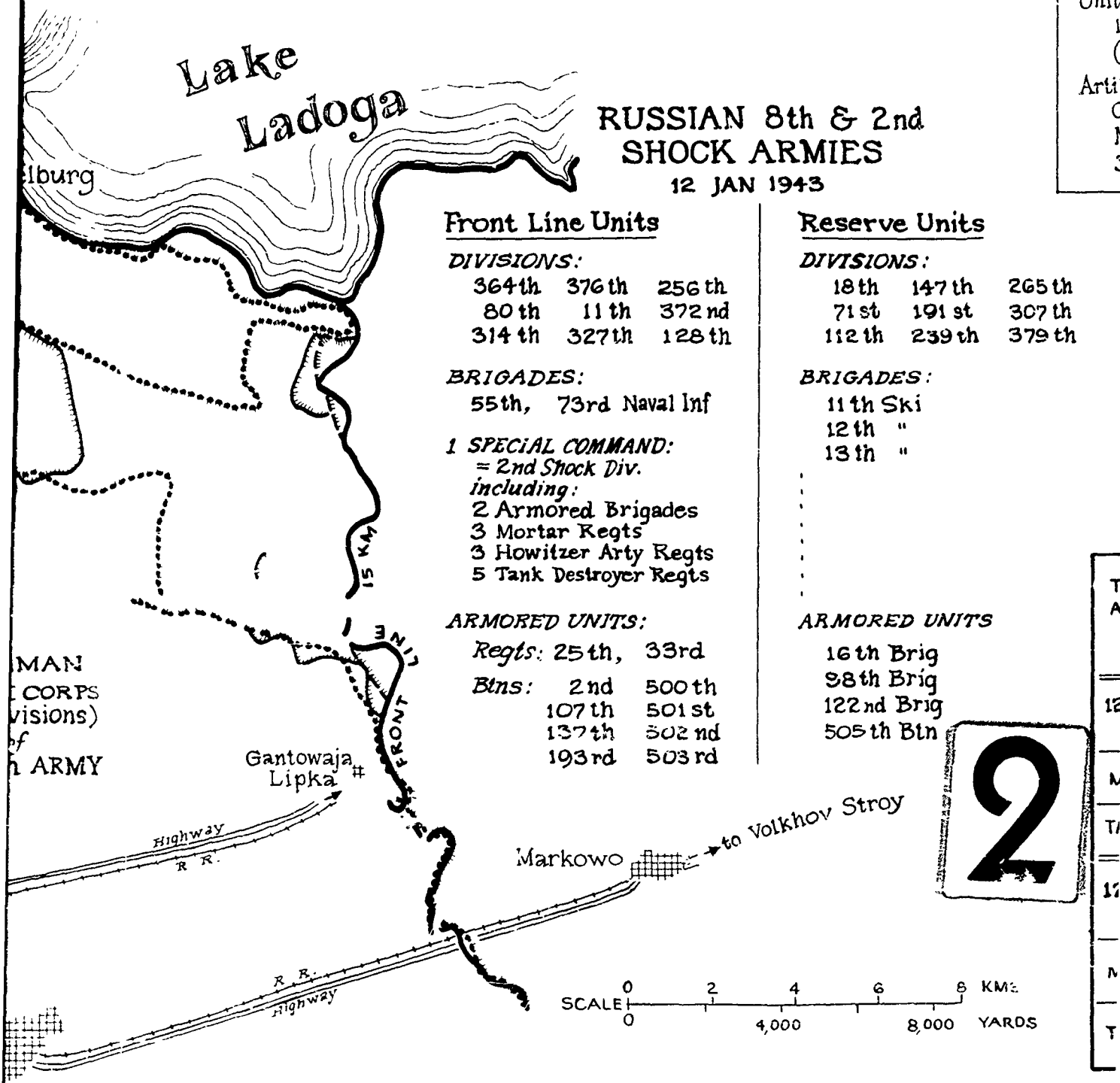
Light	16
Med	28
Heavy	5
Total	49



Legend

- GERMAN FRONT LINE 12 JAN 1943 (A.M.)
- RUSSIAN BREAK THRU 12 JAN 1943 (P.M)
- RUSSIAN BREAK THRU 13 JAN 1943 (P.M)
- RUSSIAN FRONT LINE 15 JAN 1943

SECRET



Map 23 —Volkhov Front—January 1943 (Information for Soviet Side)

Sources

Map: AOK 18, Folder 36061/200 (GMDS)

Units: Activity Report, XXVI AK, Ic, 1/1/43 to 6/30/43 Folder 34955/15 (GMDS)

Artillery: Map prepared by Senior Arty Officer 303. Appendix 1 to Br. B., No. 130/43 of 11 Jan '43, Folder 3601/200, AOK 18 (GMDS)

RUSSIAN 8th & 2nd SHOCK ARMIES

12 JAN 1943

ine Units

NS:

376th 256th
11th 372nd
327th 128th

DES:

73rd Naval Inf

L COMMAND:

Shock Div.

ing:

hored Brigades
tur Regts
itzer Arty Regts
k Destroyer Regts

ED UNITS:

: 25th, 33rd
2nd 500th
107th 501st
137th 502nd
193rd 503rd

Reserve Units

DIVISIONS:

18th 147th 265th
71st 191st 307th
112th 239th 379th

BRIGADES:

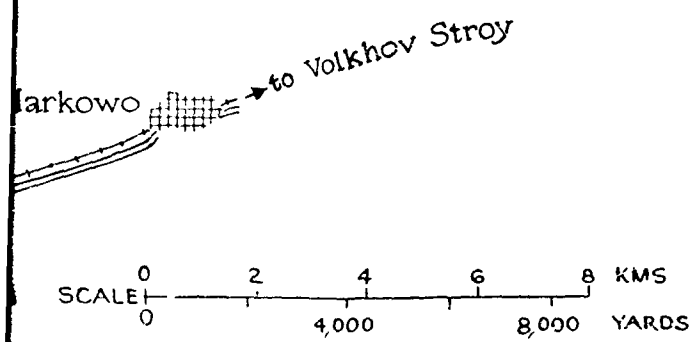
11th Ski
12th "
13th "

ARMORED UNITS

16th Brig
98th Brig
122nd Brig
505th Btn

Artillery Batteries

Light	36
Med	42
Heavy	20
Total	98



TROOPS & TANKS EMPLOYED AND LOST BY RUSSIANS ON VOLKHOV FRONT JANUARY TO APRIL 1943

12 JAN '43 to 12 FEB '43	EMPLOYED	LOST
MEN	130,000	90,000
TANKS	750	425

12 JAN '43 to 31 MAR '43	EMPLOYED	LOST
MEN	200,000 to 220,000	160,000 to 170,000
TANKS	850 to 900	641

RESTRICTED DATA
Atomic Energy Act 1946
Specific Restricted Data Contained
Use Military Characteristics
Required
Secret

ATOMIC WEAPONS EFFECT ANALYSIS ON THE GERMAN ARMY AT THE VOLKHOV FRONT

THE RUSSIAN OFFENSIVE ON THE VOLKHOV FRONT 12 JANUARY–31 MARCH 1943

OBJECTIVE

The objective was to raise the siege of Leningrad by clearing the German forces from their heavily fortified salient south of Lake Ladoga between the Neva and the Volkhov Rivers (see Map 22) and by gaining control of the Leningrad-Mga-Markowo-Volkhov Stroy railroad and highway, the main communication lines between Leningrad and unoccupied Soviet territory (see Map 23).

PLAN

Two Soviet armies, the 8th and the 2nd Shock, were to attack from the Volkhov Front on the east while a third, the 67th Army, was to attack across the Neva River from the Leningrad front on the west (Table XXIV).

The listing in Table XXIV of the Soviet units may be considered accurate since it is based on battle experience (German after-action reports) rather than on pre-battle intelligence. (See Map 23 for complete list with unit designations.)

However, it must be assumed that these Soviet units entered battle far below authorized strength. The German XXVIth Corps' reports reveal that the Soviets employed 130,000 men between 12 January and 12 February. If this number is divided by the number of divisions (24), for purposes of illustration, each division would have had a strength of 5,416 or slightly more than half of authorized strength of 9,354. If the 24 divisions alone had been at authorized strength, the total number of men in line and in reserve would have been at least 224,496. These figures do not take into account the additional infantry units and the armored units which took part in the attack. Furthermore, it is known that the Soviets had sustained heavy losses in this sector during the winter campaign of 1941–

TABLE XXIV
SOVIET STRENGTH 12 JANUARY 1943 (SEE MAPS 22 AND 23)

VOLKHOV FRONT		
8th and 2nd Shock Armies		*Artillery*
In Line	*In Reserve*	
9 divisions	9 divisions	36 light batteries
2 brigades	3 ski brigades	42 medium batteries
3 mortar regts	3 armored brigades	20 heavy batteries or a total of 98 batteries
3 howitzer regts	1 armored battalion	
5 tank-destroyer regts		
2 armored brigades		
2 armored regts		
8 armored battalions		
NEVA FRONT		
67th Army		*Artillery*
4 divisions (inf)	1 division	16 light batteries
1 garde division	4 inf brigades	28 medium batteries
2 armored brigades	1 Navy infantry brigade	5 heavy batteries or a total of 49 batteries
	1 ski brigade	
	2 battalions	
	1 armored brigade	

1942 when they made a previous [redacted] to relieve Leningrad from the Volkhov Front. At that time the original 2nd Shock Army, bearing the brunt of the attack, had been virtually liquidated by the Germans and was reconstituted as an army only after the January 1943 offensive began.

The artillery figures in Table XXIV were extracted from the German Artillery Officer's Report prepared on 11 January 1943 and based on intelligence available through 8 January. It is possible that the Soviets brought up additional artillery in the three and a half days before the attack began. Soviet sources indicate that the Soviets made long, careful preparation for artillery employment in this attack and sought to confuse and deceive the Germans as to their artillery strength and the location of their guns. This is borne out by German intelligence.

The German report mentioned previously does not give the number of guns and men per battery nor the exact location of the batteries. The Soviet report indicates that artillery was used in direct support of the infantry throughout the operation, being reorganized each night in preparation for the next day's activities.

The terrain was flat, swampy, frozen, and partly forested. The area south of Lake Ladoga was (except for the wooded and swampy shore line) frozen peat bog with several labor camps and a network of small rail lines for transporting the peat. Further south was frozen swamp and forest, all very low land. The Lake was frozen solid. Thaws in April forced a halt in the Soviet offensive.

OPERATIONS

FIRST PHASE, 12–16 JANUARY

On the morning of 12 January 1943 the Soviets attacked on a 15 kilometer front in the east and a 7½ kilometer front in the west. The attack began with 3 hours of heavy artillery fire followed by dive-bomber attacks which completed the demoralization of the German defenders. After this preparation, tanks and infantry advanced. By the end of the first day the Soviets had breached the German defenses on both fronts (see Map 23). The Soviets made further advances on 13 January. On the 15th the 2 Soviet forces advancing from the eastern and western fronts made contact with each other, dividing the German forces (Map 23). The Germans made repeated counterattacks and succeeded in evacuating part of their isolated units and in regaining ground in the Gorodok area (see Maps 23 and 24).

In four days the Soviets accomplished their first objective, the junction of the Neva and Volkhov front Armies, and the establishment of a corridor south of Lake Ladoga. However, this corridor was only 8 to 10 kilometers deep and was within range of German artillery fire.

SECOND PHASE, 16 JANUARY–1 APRIL

Between 16 and 22 January the Soviets reorganized their forces for an assault on the new German line. Their immediate objectives were the German strong point of Dubrowka and the secondary highway and rail line between Kelkotowo and Gantowaja Lipka (see Map 24).

Despite repeated attempts between 22 January and 1 April, the Soviets failed to make any headway; the spring thaw forced suspension of the operation in April. Later in the year the Germans were forced to withdraw from this area, their position becoming untenable as a result of Soviet victories south of Lake Ilmen.

The Soviets reported the forcing of a corridor to Leningrad as a great victory. Actually their achievements fell far short of their real objectives and cost an appalling number of casualties (see Maps 23 and 25). The Soviets lost 90,000 men in the first month of the offensive, and by the end of March they had lost more men than they had employed for the beginning of the offensive. The Germans called this engagement the battle that drained the Soviet infantry.

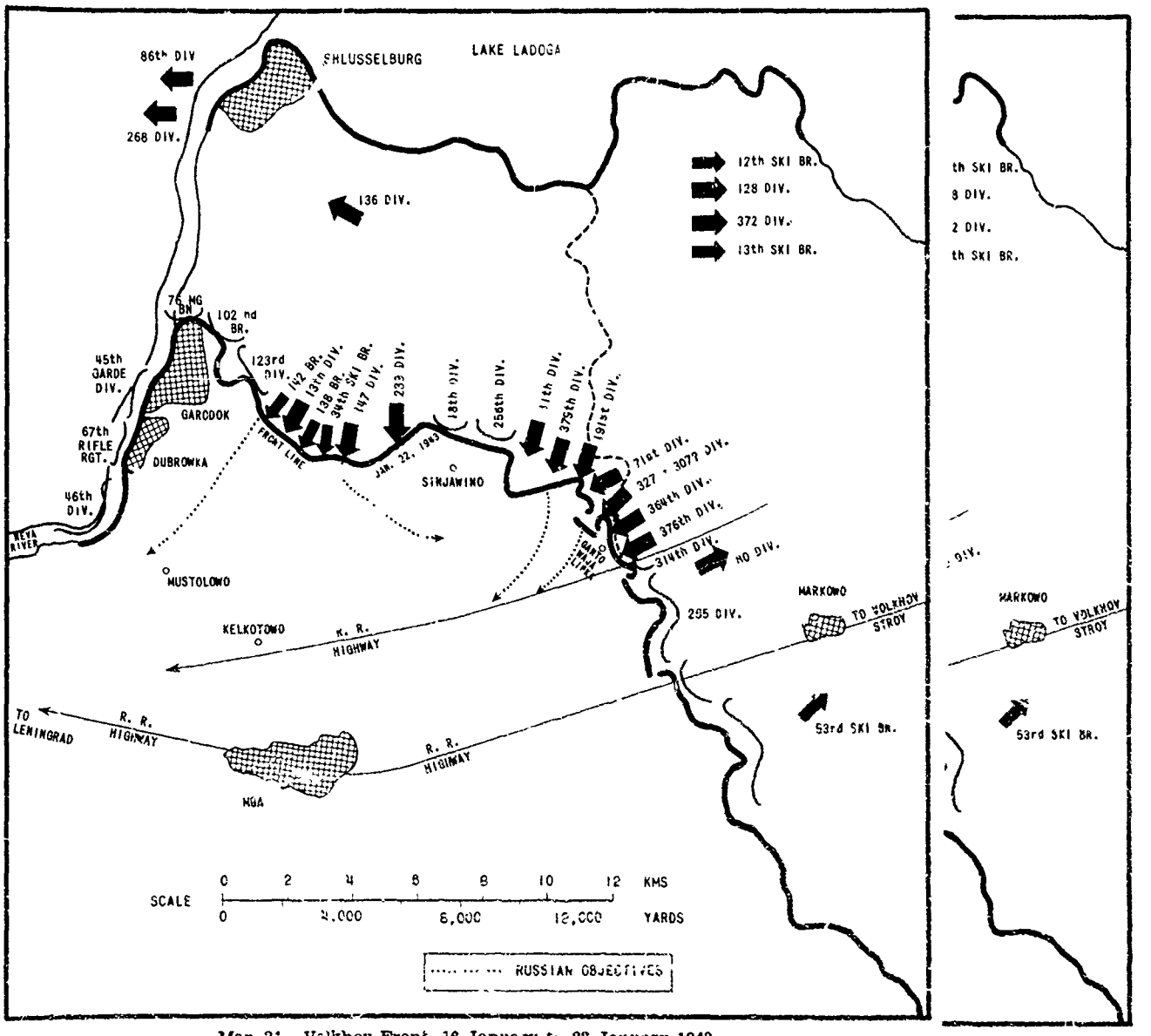
SOURCES

Soviet

Artillery War Experience in World War II; Artillery on the Volkhov Front in the Breakthrough of the Leningrad Blockade. Translated in the Service Branch, ID, by ECBP, 4

[redacted]

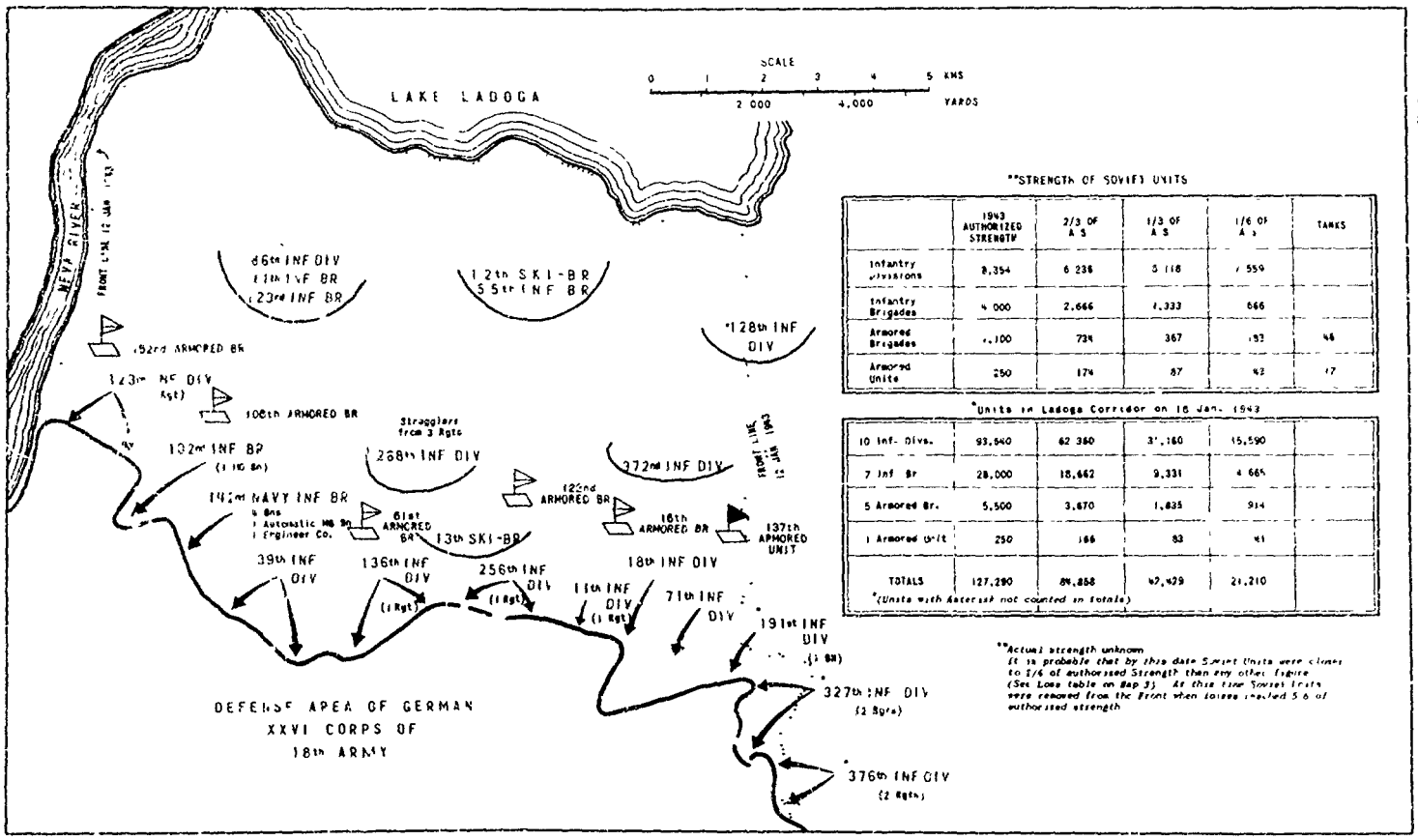
[redacted]



Map 24.—Volkhov Front, 18 January to 22 January 1943

123

Not Required



**STRENGTH OF SOVIET UNITS

	1943 AUTHORIZED STRENGTH	2/3 OF A'S	1/3 OF A'S	1/6 OF A's	TANKS
Infantry Divisions	8,354	6 236	3 118	1 559	
Infantry Brigades	4 000	2,666	1,333	666	
Armored Brigades	1,100	734	367	183	46
Armored Units	250	174	87	43	17

*Units in Ladoga Corridor on 18 Jan. 1943

10 Inf. Divs.	93,540	62 360	31,180	15,590	
7 Inf. Br	28,000	18,662	9,331	4 665	
5 Armored Br.	5,500	3,670	1,835	914	
1 Armored Unit	250	166	83	41	
TOTALS	127,290	84,858	42,429	21,210	

*(Units with Asterisk not counted in totals)

**Actual strength unknown
It is probable that by this date Soviet Units were closer to 1/6 of authorized Strength than any other figure (See Loss table on Map 3). At this time Soviet Units were removed from the Front when losses reached 5/6 of authorized strength

Situation Opposite the German XXVI Corps, 18 January 1943 (Showing Concentrations of Soviet Troops)

DEFENSE AREA OF GERMAN XXVI CORPS OF 18th ARMY
DIV (1 Bn)
327th INF DIV (2 Rgts)
376th INF DIV (2 Rgts)
**Actual strength unknown
It is probable that by this date Soviet Units were closer to 1/6 of authorized Strength than any other figure (See Loss table on Map 3). At this time Soviet Units were removed from the Front when losses reached 5/6 of authorized strength

Map 25.—Volkhov Front, Situation Opposite the German XXVI Corps, 18 January 1943 (Showing Concentrations of Soviet Troops)

[redacted]

TABLE XXV[1]

GERMAN FORCES AND ARTILLERY DEFENDING THE VOLKHOV FRONT, 11 JANUARY 1943 (SEE MAP 22) XXVI ARMY CORPS OF EIGHTEENTH ARMY

	COMPONENTS				ARTILLERY (BATTERIES)		
Divisions	Battalions	Regiments	Strength	Total	Light	Medium	Heavy
223rd	2nd	344th	319		9	7	17
	3rd	344th	439				
	2nd	385th	351				
	3rd	385th	381				
	2nd	425th	276				
	3rd	425th	302				
	1st	322nd[2]	285				
	2nd	322nd	304				
	3rd	322nd	250				
	Plus Mobile Unit 223		315	3,222			
170th	1st	391st	307		12	13	5
	2nd	391st	302				
	3rd	391st	310				
	1st	399th	304				
	2nd	399th	248				
	3rd	399th	359				
	1st	401st	315				
	2nd	401st	308				
	3rd	401st	297				
	Plus Bicycle Unit 240		310	2,960			
1st Inf.	1st	1st	448		12	9	19
	2nd	1st	511				
	1st	22nd	550				
	2nd	22nd	495				
	1st	13rd	565				
	2nd	13rd	509				
	Plus Bicycle Unit No. 1		324				
	and Light Armored Unit 1		326	3,669			
227th	1st	328th	246		12	6	20
	2nd	328th	253				
	2nd	366th	218				
	3rd	366th	214				
	1st	412th	264				
	2nd	412th	305				
	1st	374th[3]	293				
	2nd	374th	209				
	3rd	374th	270				
	Plus Mobile Unit 227		142	2,711			
96th....	2nd	283rd	160		9	6	8
	3rd	283rd	455				
	2nd	284th	390				
	3rd	284th	395				
	1st	287th	493				
	2nd	287th	490				
	Plus Mobile Unit 196		316	2,99[illegible]			
Total				15,564	54	41	69

[1] Source: Weekly Reports, Appendix—Vol. X, to KTB No. 9 of the XXVI AK from 1 January to 30 June 1943. Folder 34,55/13 (GMDS).

[2] The 3 bn of the 322nd Regt were borrowed from the 285th Security Division.

[3] The 3 bn of the 374th Regt were borrowed from the 207th Security Division.

TABLE XXVI
ESTIMATE OF NUMBER OF GERMAN PERSONNEL DEFENDING VOLKHOV FRONT

Number in organic battalions	12, 531
Number of battalions involved	39
Average number of men per battalion	322
T/O strength of battalion (before 1944)	750
Factor of attrition—322/750	.43
T/O strength per division	17, 200
T/O strength of attrition factor	7, 400
5 Divisions	37, 000
Attached personnel	3, 000–5, 000
Estimated strength	40, 000–42, 000

Feb 49. E-9500, Russian, File No. 539177. *Restricted.*

This is the report upon which certain examples in the Fort Monroe report are based. The translation is garbled and unreliable, according to ID. It is evident, however, that the author of this article is interested primarily in the technical aspects of artillery employment. Very little information is given on the operations of the infantry and armored units.

Conversation with Col Louis Ely, one of the authors of the Fort Monroe report, revealed that he supplemented the information in this report with deductions drawn from his own military experience.

German

Activity Report of the XXVIth Corps, Ic (Intelligence), 1 Jan 43 to 30 June 43, folder 34955/15 (German Military Documents Section) *Confidential.*

Appendix No 3 to *Activity Report of the XXVIth Corps, Ic,* folder 34955/18 (GMDS) *Confidential.*

Maps of the 18th Army, folder 36061/200 (GMDS) *Confidential.*

Appendix No 1 to Br. B. No. 130/43 of 11 Jan 43; map prepared by Senior Artillery Officer 303, 18th Army, folder 36061/200 (GMDS) *Confidential.*

Weekly Reports, Appendix, Vol. X, to KTB No. 9, XXVIth Corps, 1 Jan 43 to 30 June 43, folder 34955/13 (GMDS) *Confidential.*

Appendix, Vol. VII to KTB No. 9, XXVIth Corps, 11 Jan 43 to 14 June 43, folder 34955/10 (GMDS) *Confidential.*

Map 1, XXVI Corps, 11 Jan 43 (GMDS) *Confidential.*

Map 22 in this study of the USSR offensive against the Germans, January 1943, shows the German position in such detail that it deserves analysis. It is true that the Soviet concentrations in this encounter with the Germans were much greater than those of the latter. By making the present analysis it is not meant to suggest that atomic bombs could have been more profitably used against the Germans, merely that the detail about the German situation warrants a separate inspection.

It was decided to make a study first of an atomic bomb strike near the front line and compare this with a strike farther back. The first strike would fall as close to the front line as the safety of friendly troops (USSR) would allow considering the present large errors resulting from high level visual or radar bombing. It was arbitrarily decided that one may allow gamma-ray doses to friendly troops of 25 roentgens or 1 calorie per sq cm of heat radiation (in accordance with Lexington Project analysis of maximum military permissible dose to crews of nuclear powered aircraft). Thus, on the assumption that friendly troops are in fox holes and duck down at least within 0.5 seconds, the closest one may allow an air burst 20 KT atomic bomb to detonate near friendly troops is 2,000 yards when the men are wearing ordinary uniforms or 1,650 yards when special uniforms designed to protect against heat radiation are being worn.

It follows that if the clearance between the aiming point and the friendly front line is 2,000 yards plus 2 circular probable error lengths, then the probability is 6.3 percent that some friendly personnel will stand a chance of receiving more than the maximum permissible dose.

A reasonable clearance of 1,700 yards behind the enemy front line was chosen for a weapon very accurately placed and 3,000 yards for an inaccurate weapon, since high altitude radar bombing accuracy is apparently considered 1,000 yards circular probable error

A comparison of the damage resulting from these two different drops reveals that the near drop affected front-line troops primarily and had but a minor effect on battalion and regi-

mental headquarters and light artillery batteries. The far drop, on the other hand, had a minor effect on front line troops and a major effect on artillery, regimental headquarters, and a few higher headquarters. This difference suggested a separate analysis of the efficacy of a series of atomic-weapon drops against front line troops versus the same number of bombs dropped against artillery.

The total number of Germans in the corridor is not definitely known. In the historical study previously presented in this Enclosure, data are presented showing that the battalion strength of the Germans had been reduced to 43 percent of T/O. The 1 January 1943 German monthly reports of losses indicate that the division artillery was up to about 92 percent of T/E strength in weapons (guns, howitzers, et cetera) and presumably near this figure in personnel. It was, therefore, decided arbitrarily to assume that all artillery units were up to 100 percent strength and all other units were only 43 percent of T/O strength. Since a full division in 1943 had a T/O of 17,200 persons of which 2,500 were an artillery regiment, the previous assumptions would give 8,000 men as the average strength per division. The 5 divisions of Germans in the Volkhov corridor would contain 40,000 men in addition to some 3,000–5,000 men in miscellaneous attached units.

NEAR-DROP VERSUS FAR-DROP

To proceed with the analysis, it is necessary to make the following simplifying assumptions concerning the degree of protection given to the combat personnel:

All front line troops are dispersed and the men are in fox holes (see Figure 25).

Headquarters personnel are 50 percent in the open and 50 percent in fox holes or in equivalent shelters.

Personnel at the batteries of all artillery units are in the open.

Two positions, one for a near hit and one for a far hit, were selected which appeared to yield the greatest casualties. The near hit was put 1,700 yards from the friendly front line (see Map 26). The radial distance from ground zero of each unit was measured and the number of casualties estimated from the damage curves in Figures 25 and 27. The results of the analysis are summarized in Table XXVII, for troops in the present ordinary uniform and for troops in a uniform especially designed to reflect a large portion of the heat from the burst. This latter uniform gets so hot that it must be discarded immediately after the burst has subsided; but a man so clothed is still vulnerable to gamma radiation.

One main point brought out by this table is the great difference in vulnerability of artillery troops in the open and front line troops in fox holes. Although the density of troops is greatest near the front line, the far drop will be found to cover approximately the same number of personnel as the near drop. This apparent anomaly is due to the fact that a considerable area of the near hit is over friendly troops. In terms of total casualties the far hit seems more effective but the efficacy of the near hit is increased as it approaches closer to the front. To place it in optimum position requires a clearance between the lines of at least 1,000 yards (1,000 yards plus 2 circular probable error of placement).

The apparent great advantage of wearing special uniforms is somewhat illusory since it is necessary to shed the uniform immediately after the atomic weapon attack is over. Troops are forced to get rid of their special uniforms while in a highly vulnerable position for attack by a second atomic weapon. Thus if 2 atomic bombs are dropped in succession against troops equipped with special uniforms, the second bomb would catch the troops in the open and unprotected. The very best, then, that the special uniform can do is to require 2 atomic bombs to do the job that 1 atomic bomb would do against troops in ordinary uniform.

Another significant result is the high casualty rate against artillery personnel by the far hits, and the poor effect of far hits against front line troops.

The far hit is more typical of our present capabilities since the US does not possess a weapon system capable of the accuracy required for the close attack. This analysis is some indication of the necessity for the greater accuracy which could be achieved by a guided missile.

TABLE XXVII

ESTIMATED CASUALTIES IN VARIOUS CATEGORIES FOR NEAR HIT AND FOR FAR HIT—THE RANGE OF VALUES INDICATED IS THAT RESULTING FROM UNCERTAINTY AS TO NUMBER OF TROOPS IN VOLKHOV CORRIDOR

	PERCENT OF TROOPS DEPLOYED (IN FOX HOLES) IN GIVEN CATEGORY		PERCENT OF BQ TROOPS (½ IN OPEN) IN GIVEN CATEGORY		PERCENT OF ARTILLERY TROOPS (IN OPEN) IN GIVEN CATEGORY		PERCENT OF TOTAL PERSONS IN CIRCLE OF 5,000 YD RADIUS IN GIVEN CATEGORY		TOTAL PERSONS IN CIRCLE OF 5,000 YD RADIUS IN GIVEN CATEGORY	
	Near Hit 1,700 Yards From Front Line									
	OU[1]	SU[2]	OU	SU	OU	SU	OU	SU	OU	SU
Immediate Casualties	8 9		31. 8		45. 2		24 -30		1, 210–2, 520	
		5. 9		0		0		1 8–3. 0		15+
Immediate Deaths	4. 0		18 8		11 0		8 8–10 8		445– 900	
		1 4		0		0		0 8–0. 5		38
Delayed Deaths	2. 0		0		0		1. 0– 0 6		52	
		4. 5		4. 8		0. 5		3 4–2 9		170–240
Total Personnel	2, 617		932–2, 171		1, 508–3, 514				5, 057–8, 302	
	Far Hit 5,000 Yards From Front Line									
Immediate Casualties	0		37. 6		79. 1		37 -50		1, 825–4, 250	
		0		0 7		15. 6		6 -8		300–700
Immediate Deaths	0		18. 3		55. 4		25 -33		1, 200–2, 800	
		0		0		6. 5		2. 5–3 3		120–200
Delayed Deaths	0		0		0		0		0	
		0		1. 0		12 2		5 -6. 5		240–550
Total Personnel	2, 081		910–2, 120		1, 877–4, 374				4, 868–8, 575	

[1] OU equal Ordinary uniform.

[2] SU equal Special uniform designed to reduce injury from heat of atomic weapon.

ATOMIC WEAPON OPERATION AGAINST FRONT LINE TROOPS

In designing an optimum attack against front line troops, such as would occur in preparation for a breakthrough, a portion of the German front was selected in which the division frontage is about 7,000 yards (see Map 27). Several qualitative observations can be made.

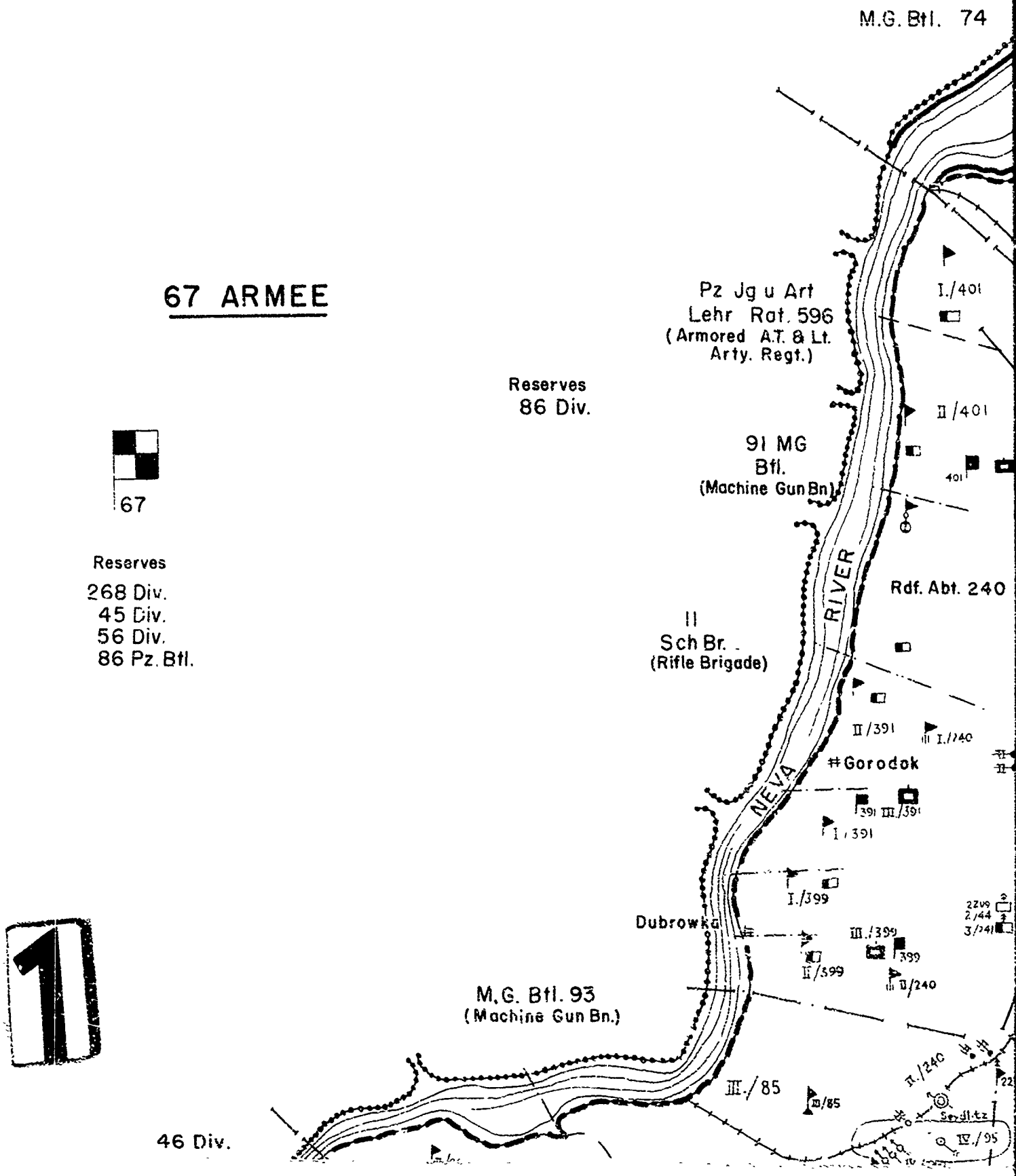
1. With present bombing errors estimated at 500 yards circular probable error for visual bombing and 1,000 yards circular probable error for radar bombing, the required clearance of friendly front line troops for radar bombing is about 2,000 yards plus 2 circular probable error, or about 4,000 yards. This distance is too great to secure optimum effect.

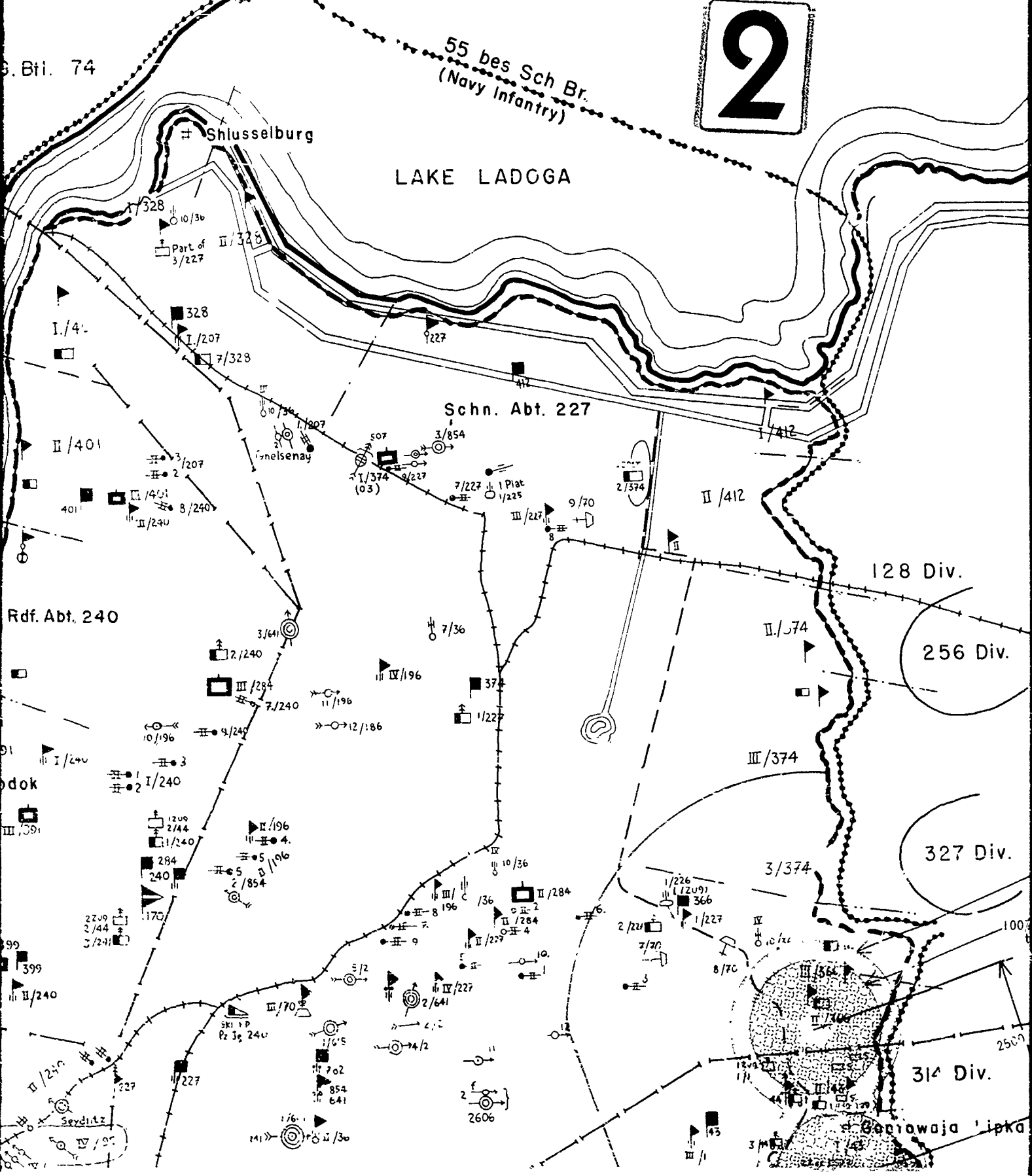
2. The atomic weapons should burst about 1,000 yards behind the enemy front line for maximum effect against front line troops in fox holes.

3. To comply with safety requirements for friendly troops, there should be a separation between front lines of 1,000 yards plus 2 circular probable error. This may require a withdrawal of the friendly troops just prior to the attack.

4. Since battalion and regimental headquarters in the German Army are from 1,000 to 3,000 yards behind their front lines, they are highly vulnerable to atomic weapon attack. This is especially true of their communication lines which are in the open.

5. The effectiveness of bomb bursts adjacent to each other is augmented in that some damage is additive (e.g., gamma radiation) and the probability of no-damage is multiplicative. The resulting damage area, therefore, is greater than if the 2 bursts were placed separately. The drawing of the 100 percent and just 0 percent casualty contours in Map 27 is a crude attempt to estimate this effect. Since the original curves are poorly determined, an accurate calculation of this overlapping effect is not now warranted. A spacing of 2,500 yards seems to be near optimum for this additive effect. Note that this spacing refers to an attack against troops in a defensive position.


M.G. Btl. 74
67 ARMEE
Pz Jg u Art
Lehr Rat. 596
(Armored A.T. & Lt.
Arty. Regt.)
I./401
Reserves
86 Div.
II/401
91 MG
Btl.
(Machine Gun Bn)
401
67
Reserves
268 Div.
45 Div.
56 Div.
86 Pz. Btl.
Rdf. Abt. 240
II
Sch Br.
(Rifle Brigade)
RIVER
II/391
I./240
#Gorodok
NEVA
391
III./391
I./391
I./399
Dubrowka
III./399
399
II/399
II/240
M.G. Btl. 93
(Machine Gun Bn.)
II./240
III./85
III/85
IV./95
46 Div.


2
55 bes Sch Br.
(Navy Infantry)
Shlusselburg
LAKE LADOGA
Schn. Abt. 227
128 Div.
256 Div.
327 Div.
314 Div.
Rdf. Abt. 240
Part of 3/227
Gnelsenay
Seydlitz
Gorlowaja Lipka

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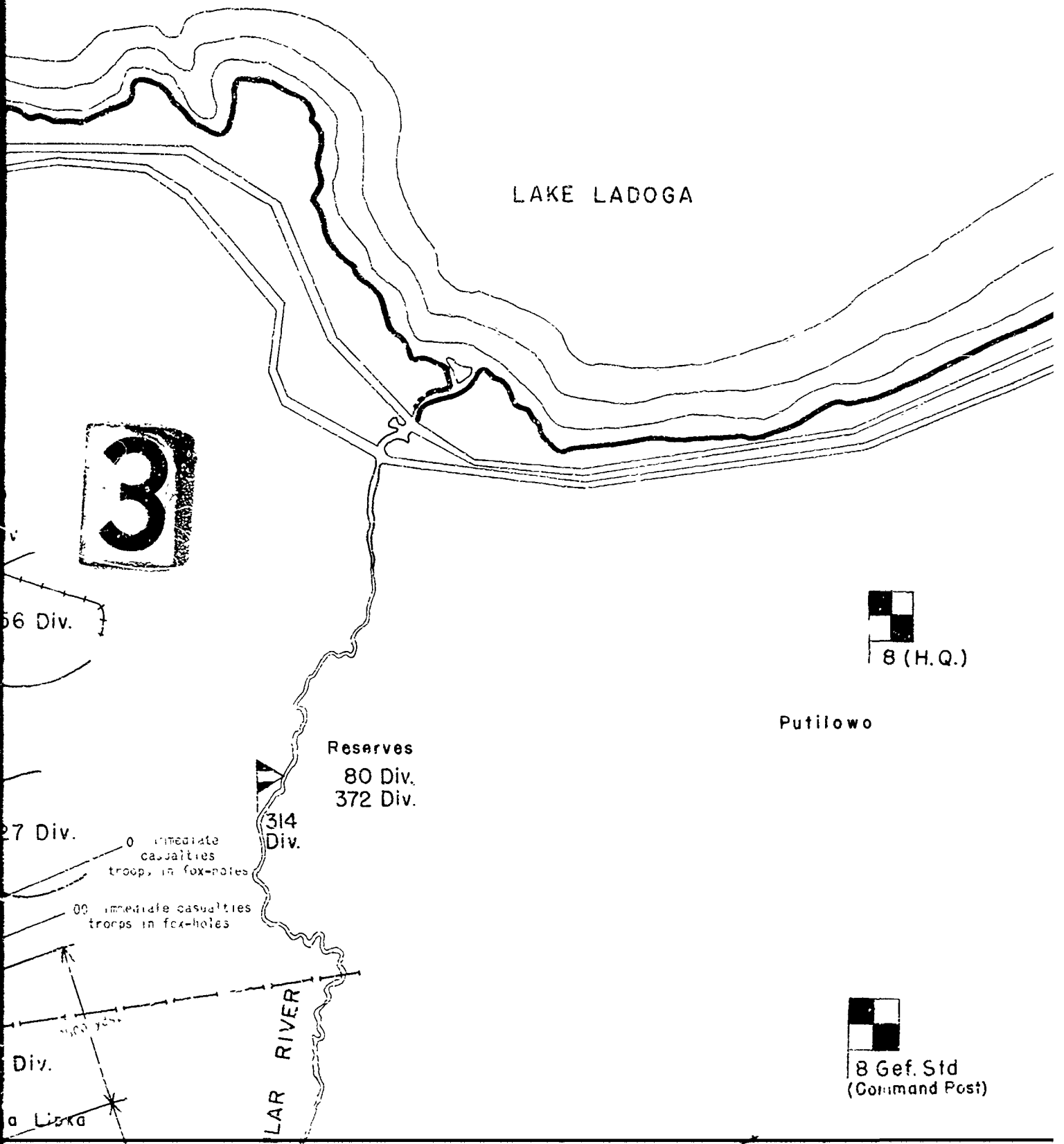
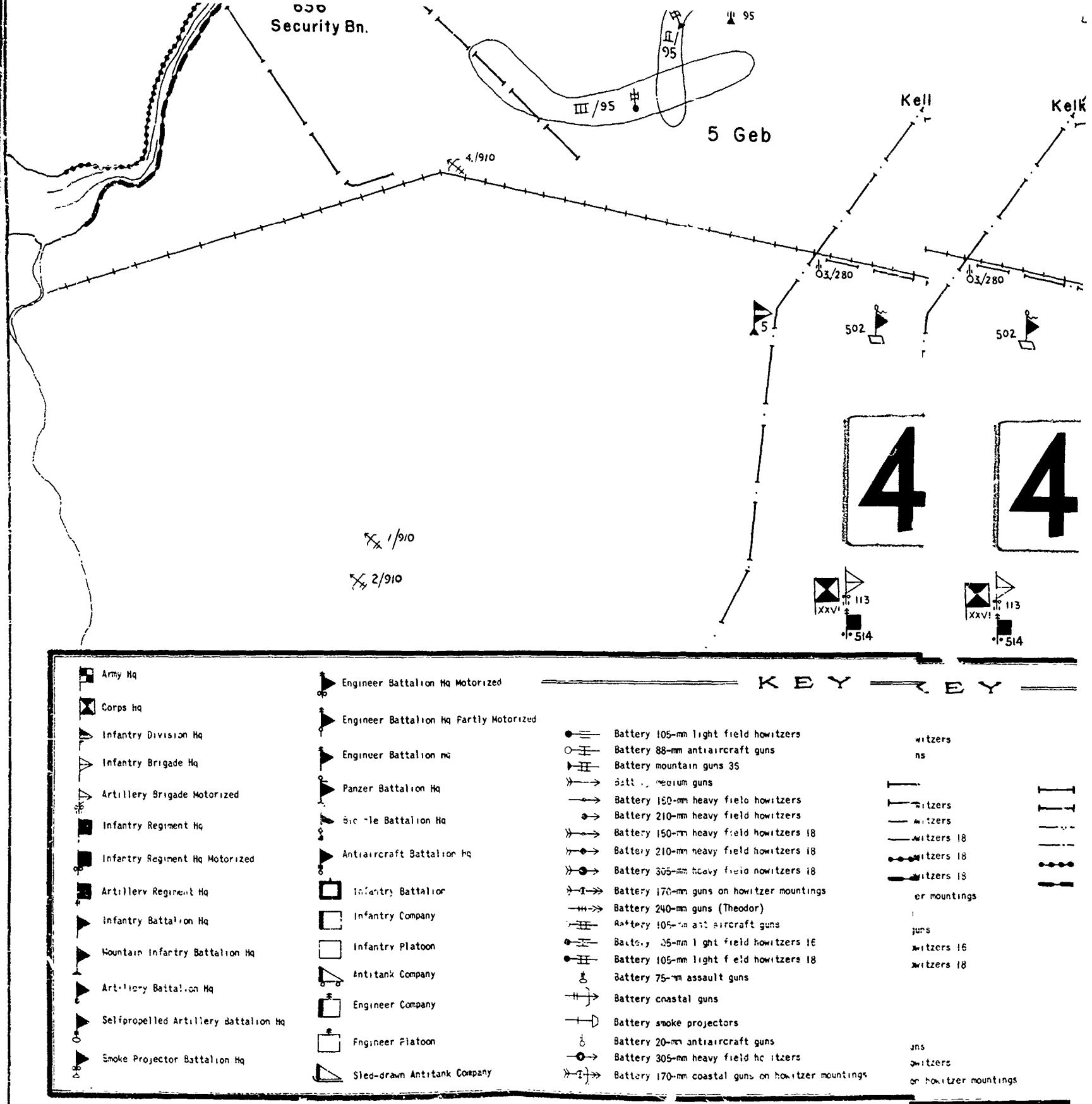
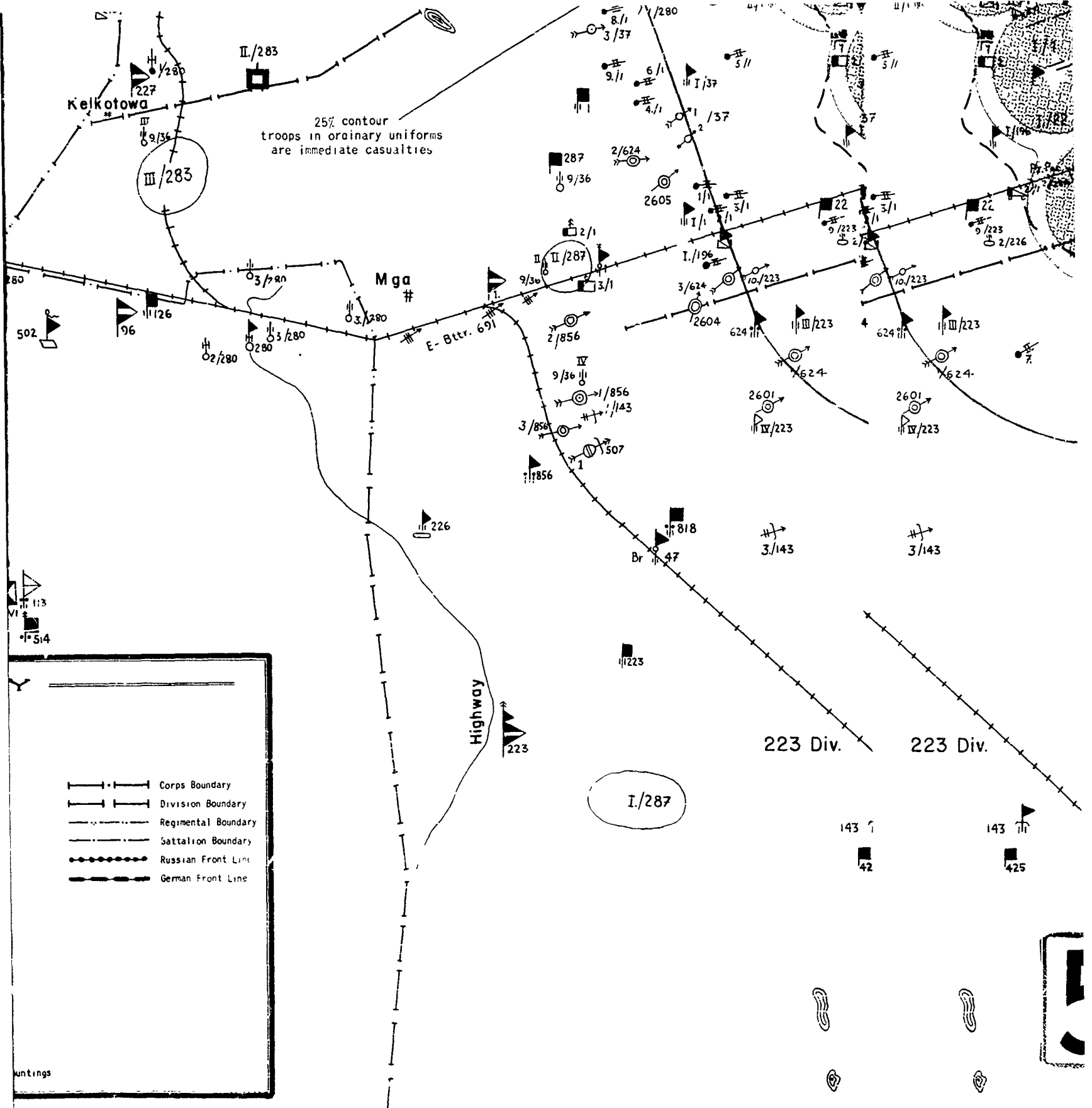
[redacted] Atomic Energy Act - 1946
[redacted] Clearance [redacted] Requ
[redacted] Safeguards

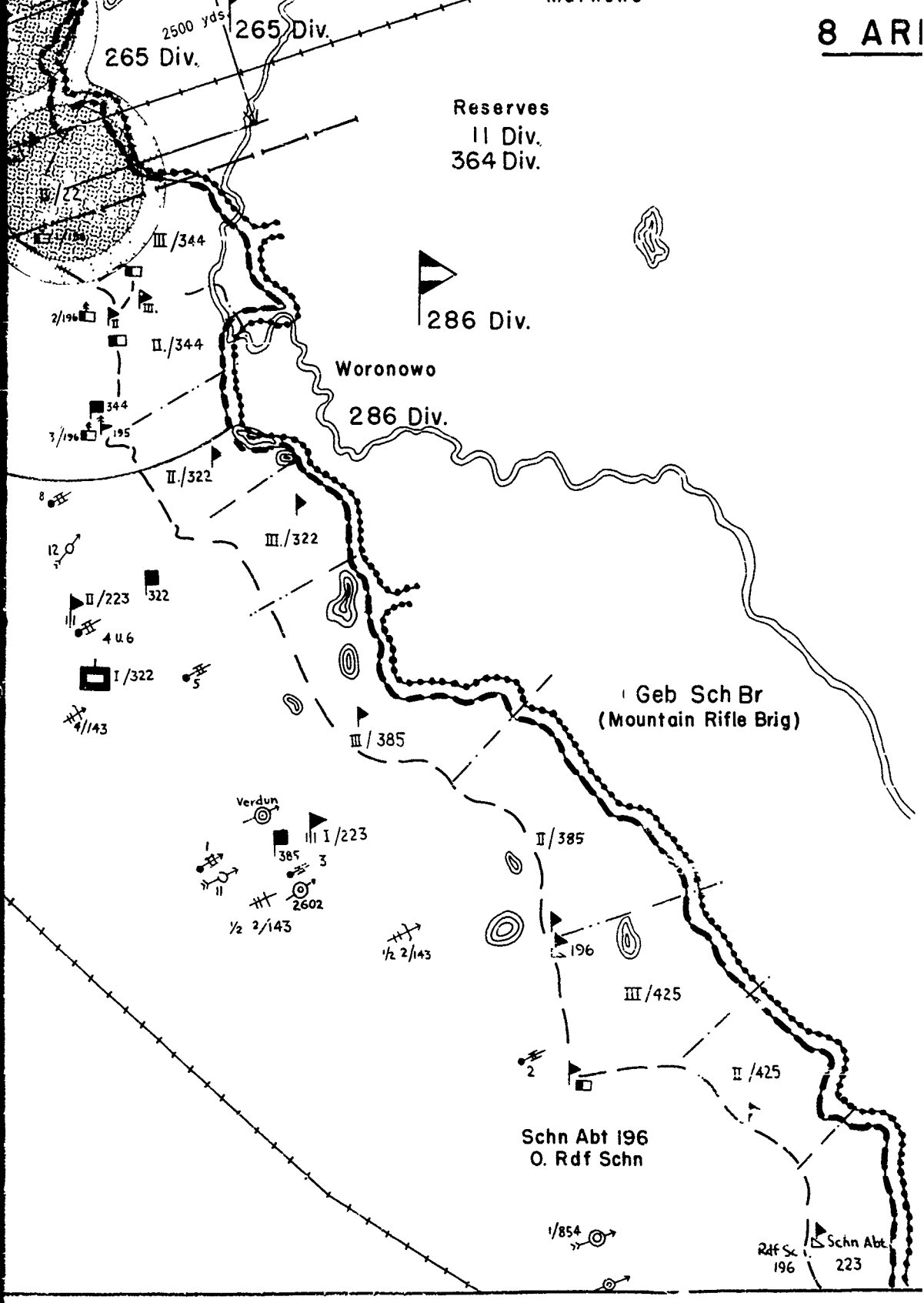


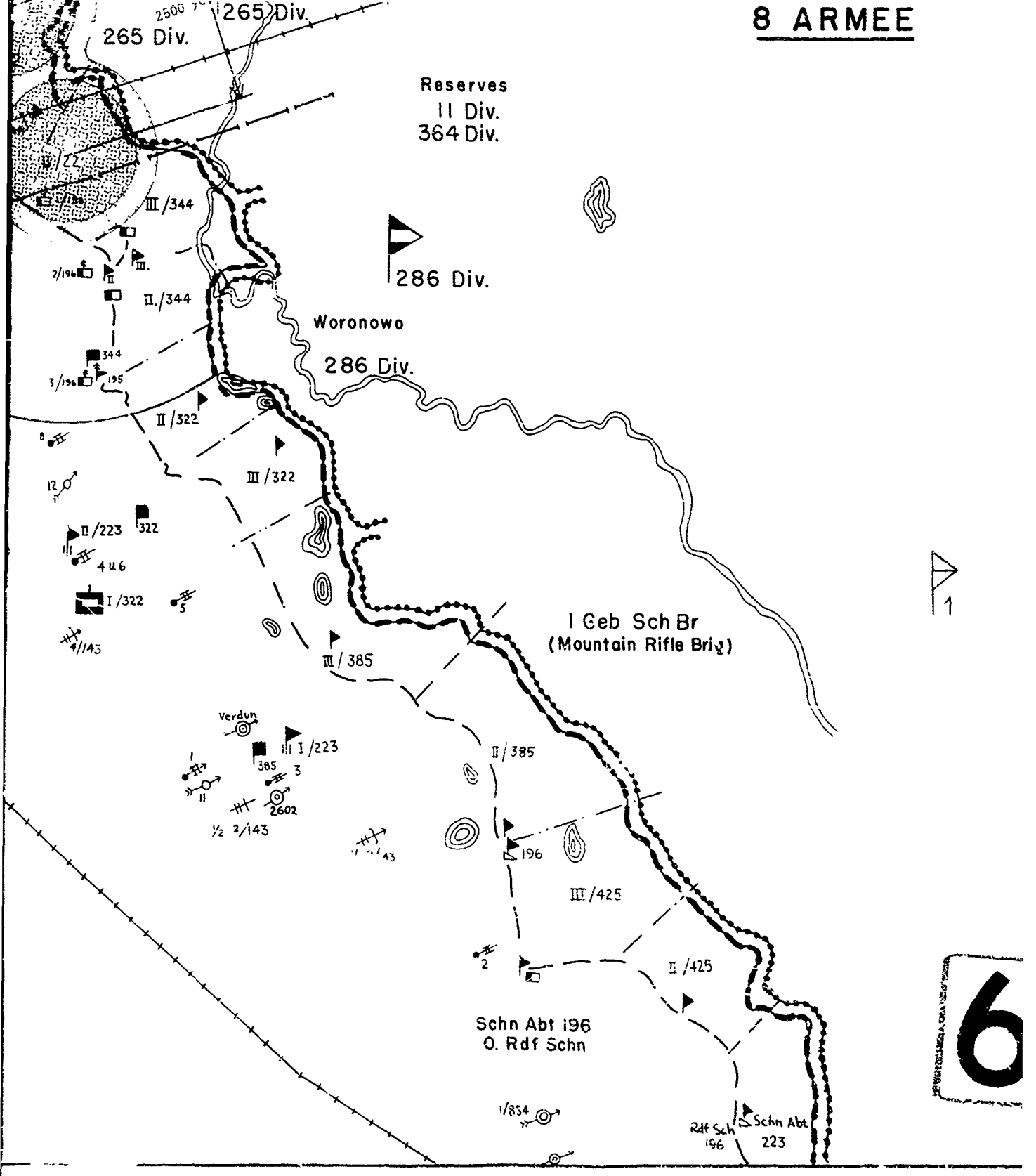

656
Security Bn.
95
II/95
III/95
5 Geb
Kell
Kelk
4./910
03/280
03/280
5
502
502
4
4
1/910
2/910
XXVI
113
514
XXVI
113
514
KEY
KEY
Army Hq
Corps Hq
Infantry Division Hq
Infantry Brigade Hq
Artillery Brigade Motorized
Infantry Regiment Hq
Infantry Regiment Hq Motorized
Artillery Regiment Hq
Infantry Battalion Hq
Mountain Infantry Battalion Hq
Artillery Battalion Hq
Selfpropelled Artillery Battalion Hq
Smoke Projector Battalion Hq
Engineer Battalion Hq Motorized
Engineer Battalion Hq Partly Motorized
Engineer Battalion Hq
Panzer Battalion Hq
Bicycle Battalion Hq
Antiaircraft Battalion Hq
Infantry Battalion
Infantry Company
Infantry Platoon
Antitank Company
Engineer Company
Engineer Platoon
Sled-drawn Antitank Company
Battery 105-mm light field howitzers
Battery 88-mm antiaircraft guns
Battery mountain guns 35
Battery medium guns
Battery 150-mm heavy field howitzers
Battery 210-mm heavy field howitzers
Battery 150-mm heavy field howitzers 18
Battery 210-mm heavy field howitzers 18
Battery 305-mm heavy field howitzers 18
Battery 170-mm guns on howitzer mountings
Battery 240-mm guns (Theodor)
Battery 105-mm antiaircraft guns
Battery 105-mm light field howitzers 16
Battery 105-mm light field howitzers 18
Battery 75-mm assault guns
Battery coastal guns
Battery smoke projectors
Battery 20-mm antiaircraft guns
Battery 305-mm heavy field howitzers
Battery 170-mm coastal guns on howitzer mountings



Map 27.—Design of Atomic Weapon Attack against Troops in a Defensive Position

e Position


2500 yds
265 Div.
265 Div.
Reserves
11 Div.
364 Div.
III/22
III/344
2/196
II.
III.
II./344
286 Div.
Woronowo
286 Div.
344
3/196
195
II./322
8
III./322
12
II/223
322
4 u. 6
I/322
5
4/143
Geb Sch Br
(Mountain Rifle Brig)
III/385
Verdun
I/223
385
3
2602
½ 2/143
II/385
½ 2/143
196
III/425
2
II/425
Schn Abt 196
O. Rdf Schn
1/854
Rdf Sc
196
Schn Abt
223


8 ARMEE
265 Div.
265 Div.
Reserves
11 Div.
364 Div.
III/344
286 Div.
II./344
Woronowo
286 Div.
II/322
III/322
II/223
322
I/322
I Geb Sch Br
(Mountain Rifle Brig)
III/385
Verdun
I/223
385
2602
½ 2/143
II/385
196
III/425
II/425
Schn Abt 196
O. Rdf Schn
1/854
Rdf Sch 196
Schn Abt 223
1

6

RESTRICTED DATA
Atomic Energy Act of 1946
Contains Information Affecting the National Defense of the United States within the meaning of the Espionage Laws, Title 18 U.S.C., Sections 793 and 794. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

6. From a pattern such as drawn in Map 27, one would expect 100 percent casualties out to 2,000 yards behind enemy front lines.

7. If troops are dug in, the regimental reserves which are not committed to a position close behind front line troops are usually not immediate casualties. Note that the fox hole herein considered is the smallest that a man can get into.

8. Three bombs per division front of 7,500 yards are required completely to neutralize front line troops (i.e., one bomb per regiment if frontage is 2,500 yards per regiment).

9. If the division frontage is decreased, the number of bombs per division will tend to remain constant, since the division will increase in depth. The experience at St. Lo is an example of this. Here the frontage was 6,000 yards for 5 US divisions and these extended in depth to more than 9,000 yards. The area per division was 1.6×10^7 yards^2. The area of the German 1st Division (front line troops, not artillery) was 7,000 yards wide by 2,000 yards deep, or 1.4×10^7 yards^2.

10. A bonus effect is obtained by the neutralization of a large fraction of the light artillery (about 80 percent) as well as damage to regimental and battalion headquarters. Very little medium and heavy artillery is affected.

11. Reserves which are dug in or otherwise protected and farther than 2,000 yards from the center of the line of bomb hits will not suffer appreciable immediate casualties.

12. If communications depend on field wire laid along the surface of the ground or suspended in trees, it will be entirely disrupted.

13. When the division holds a frontage of more than 7,000 yards, bombs per frontage tend to remain constant. Beyond 7,000 yards, therefore, the bombs per division increase directly with increase in division's frontage.

14. The accuracy required in the placement of bombs for near optimum effect is: circular probable error of 250 yards or better.

More detailed analysis on the basis of the same assumptions as to number of troops in fox holes, in the open, et cetera, used previously, reveals that 89 percent of personnel covered by the 25 percent contour for immediate casualties would become immediate casualties if they wore ordinary uniforms and were in the open (see Table XXVIII).

TABLE XXVIII
IMMEDIATE CASUALTIES FROM THREE BOMBS DROPPED ON 1ST DIVISION (ORDINARY UNIFORMS)

	NO. IMMEDIATE CASUALTIES	PERCENT	TOTAL NUMBER IN PATTERN
Deployed troops	2,352	91	2,417
Artillery personnel	1,095	70	1,564
Headquarters personnel	253	50	506
Total	3,700		4,175

It should be noted that these calculations apply to *troops on the defensive*. Much higher casualties should result when the atomic weapon is used against troops on the offensive. The atomic weapon spacing required would be more in the order of 1 weapon per division front of 7,500 yards.

ANTI-ARTILLERY OPERATION

The assessment of the effectiveness of an air burst atomic weapon against artillery is complicated by the degree of uncertainty as to the disposition and protection of personnel at any one instant.

Gun emplacements with a 3½ ft parapet as depicted in FM 6-101 p. 251 afford very little protection to personnel in the act of manning the gun. The parapet is not high enough to cause appreciable shadow for heat protection except for atomic weapon bursts at approximately 5,000 yards. The special trenches dug for personnel protection in case of strafing are too far from the operating positions to allow the personnel to duck into them in time to reduce the heat dosage appreciably. Men in the ammunition handling pit would be protected from atomic weapon bursts in *one* direction up to about 1,000 yards. One may conclude that personnel manning a gun in an emplacement of World War II variety are essentially in the open as regards their vulnerability to harm by an air burst atomic weapon.

Personnel off-duty would be resting in an exposed position if danger from strafing aircraft were unlikely and the atomic weapon unknown. On the other hand, a small amount

of strafing, or the threat of use or past use of an atomic weapon should certainly serve as sufficient motivation for off-duty personnel to seek shelter of some kind—shelter which would protect them from the heat effects of the atomic explosion.

In a static position, one must obviously await a time when the enemy artillery is active, otherwise a large fraction of the personnel would be in protective positions. On the other hand, if an attack is imminent (say an attack by Soviet troops) large quantities of artillery may be in process of placement during the night. Since most of the personnel are in active exposed positions during an emplacement, if the enemy can be caught with a large fraction of his artillery in motion, large casualties to his artillery would result (50 percent out to approximately 3,800 yards from the burst, i.e., the exposed artillery behind a frontage of about 7,000 yards would have 50 percent or more of its personnel immediate casualties, and 100 percent casualties behind a frontage of 5,500 yards). To catch an enemy so exposed requires almost perfect knowledge of his movements.

As a more realistic picture, suppose the enemy artillery is not attacked until its activity rises to a high level leading one to suppose an attack is in preparation. An atomic weapon over the artillery would then neutralize immediately a wide circle of artillery. Assuming that one-half of the personnel are present at the guns, and that one-third of these—or one-sixth of the total—can man the guns effectively, then the radius of immediate incapacitation of artillery would be 3,300 yards. Those units between ground zero and about 1,000 yards would be completely neutralized, since the resting men would become casualties although protected by fox holes, et cetera. Those units between 1,000 yards radius and 3,300 yards radius would have a reserve of resting men who could be mustered and put to work manning the guns in a short time.

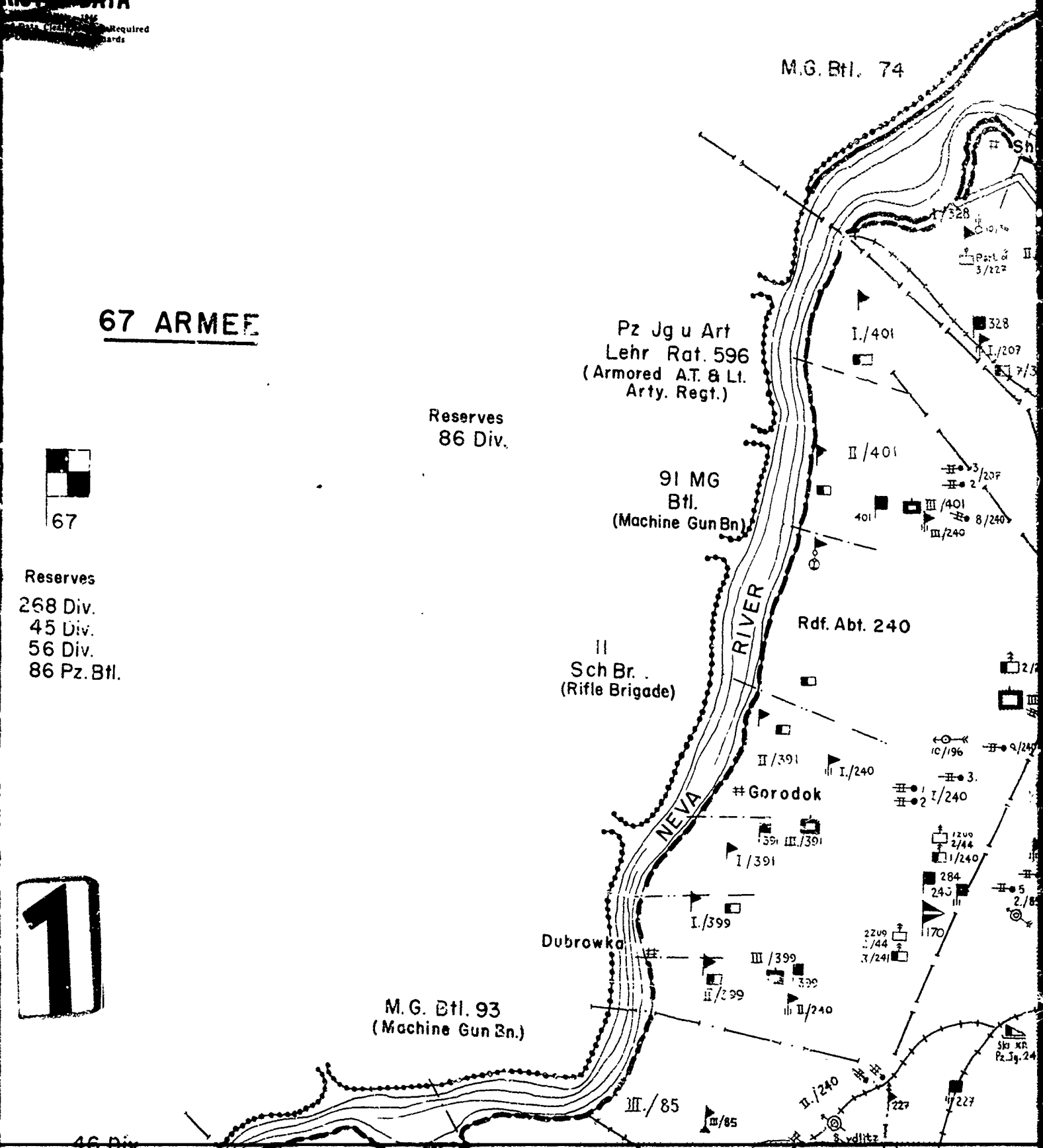
Battalion Headquarters troops are assumed to be dug in, in emplacements similar to those pictured in *FM* 6-101, pp. 240 and 241. These emplacements afford imperfect protection. One may estimate that the 100 percent immediate casualty zone would be the same as for fox holes (about 700 yards) while the zero effect zone would be out to more than 4,000 yards. This large range of values results from the peculiar U-shaped entrenchments and from the assumption that the fortification would present a random orientation to the atomic weapon burst.

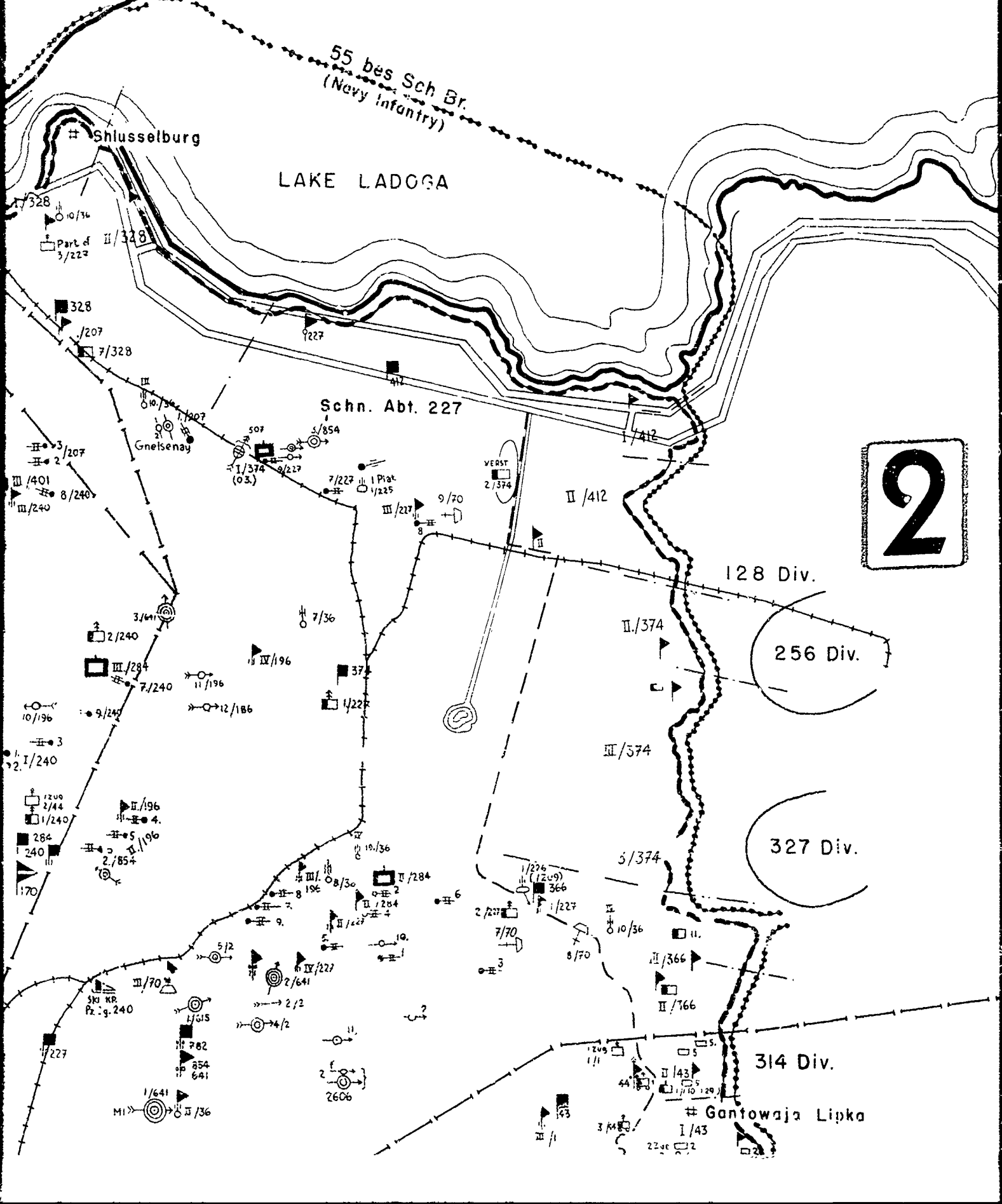
The disruption of wired communications is an important effect. On the assumption that at least 100 calories per sq cm would be necessary to burn the field wire sufficiently to make it useless, the circle of effectiveness against such wire would have a radius of about 700 yards. The additional disruption of radio communications is also uncertain. Since the radio sets can withstand fairly severe shocks, the radius of effectiveness against units in dug-outs uncovered must not be greater than the radius for 100 percent damage to personnel. Radio equipment mounted a few feet above the surface of the ground might suffer considerable damage out to about 2,000 yards from the wind produced by the explosion.

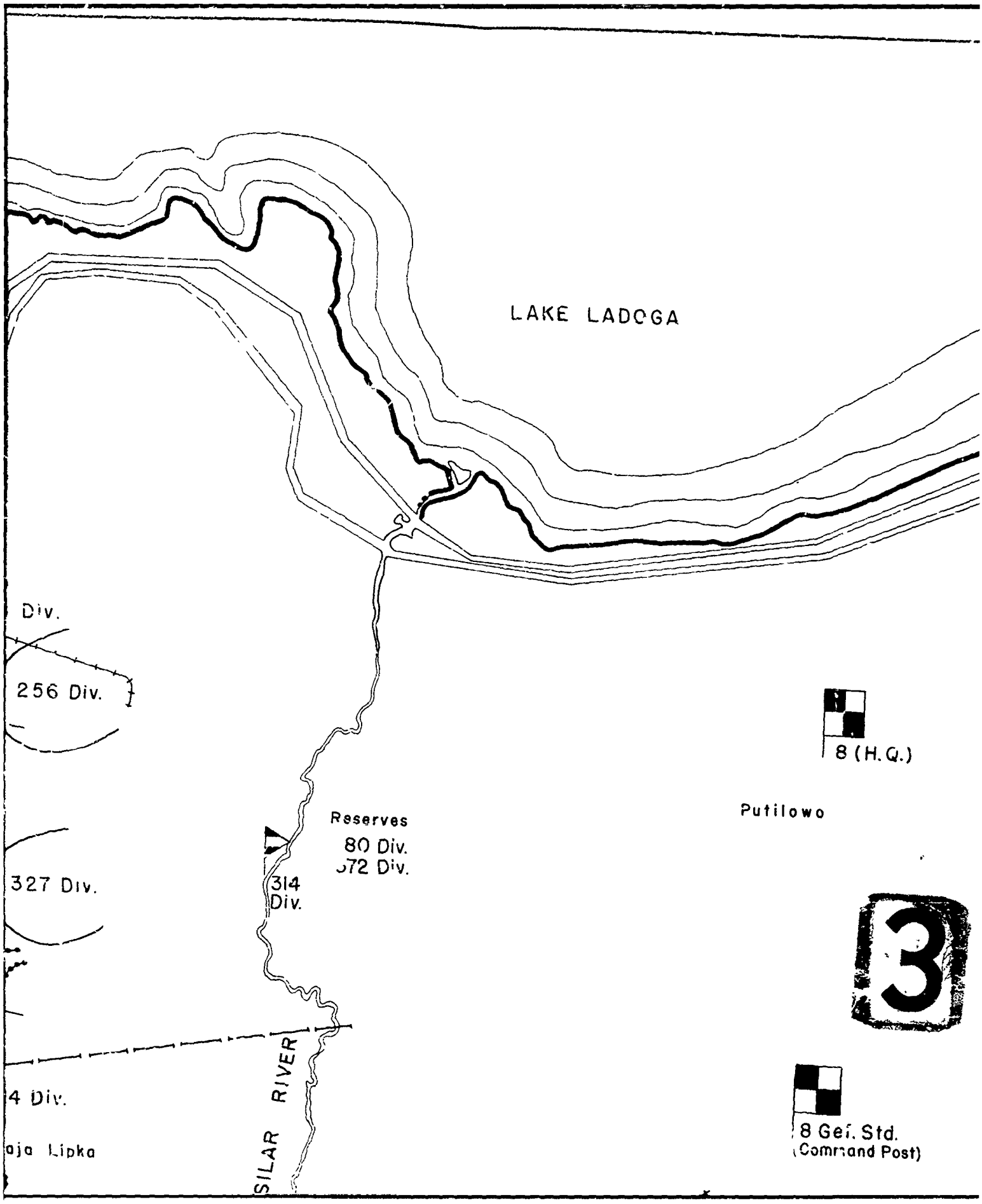
Wire repairmen will generally be in the field half the time, and in open vulnerable positions. These men are highly important to the communications system since they require considerable training and experience. Their loss would have a delaying effect on the efficiency of the artillery operation. It seems reasonable to conclude, therefore, that the immediate effectiveness of an atomic weapon against communications within the artillery is likely to be confined to a circle within 1,000 yards.

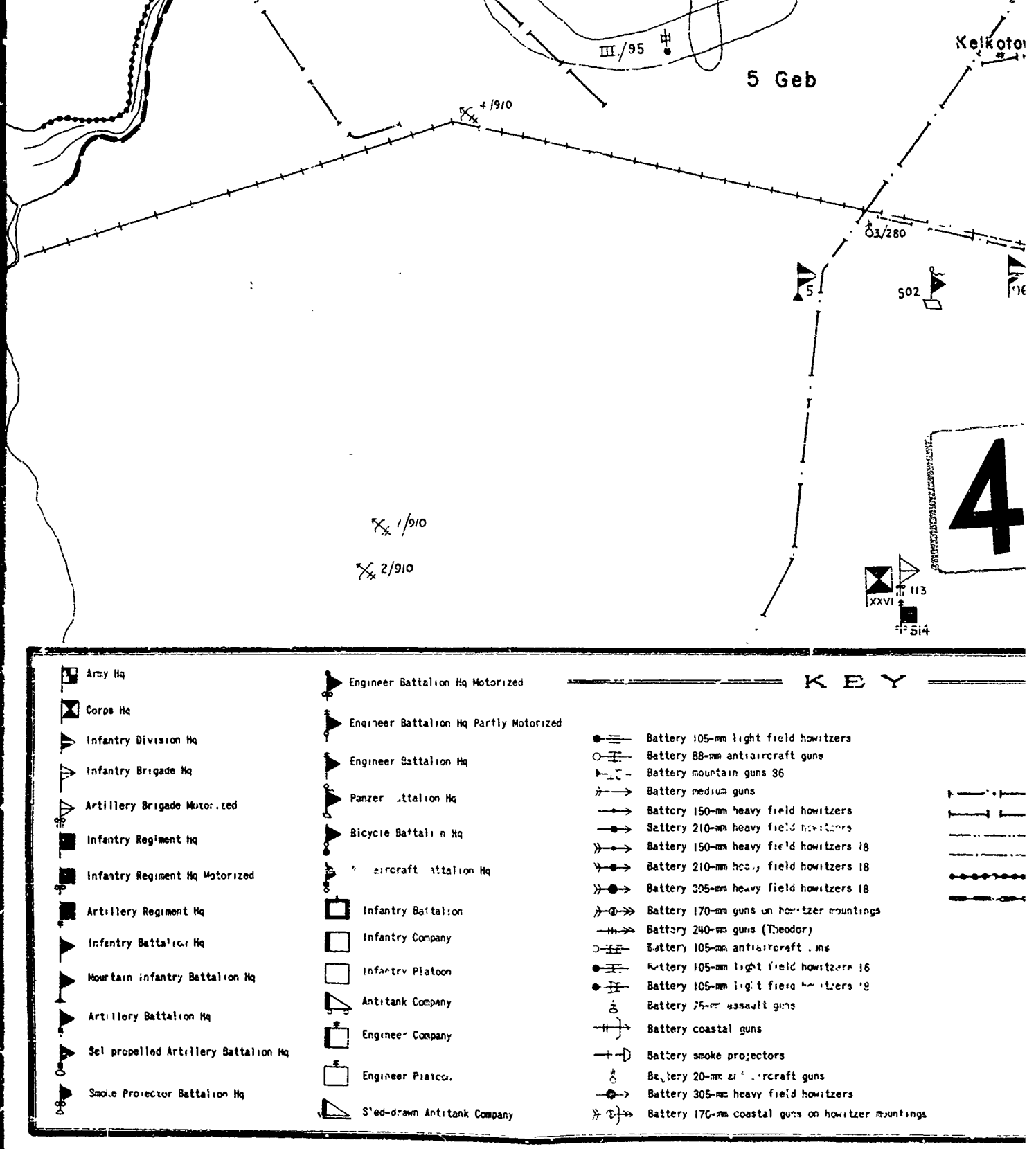
Thus, for artillery strung out behind a frontage of 7,000 yards, the immediate effect of an atomic explosion over the artillery area would be to silence all batteries behind this frontage. In a short time the batteries along 5,000 yards of this frontage should resume operations, some with reduced effectiveness.

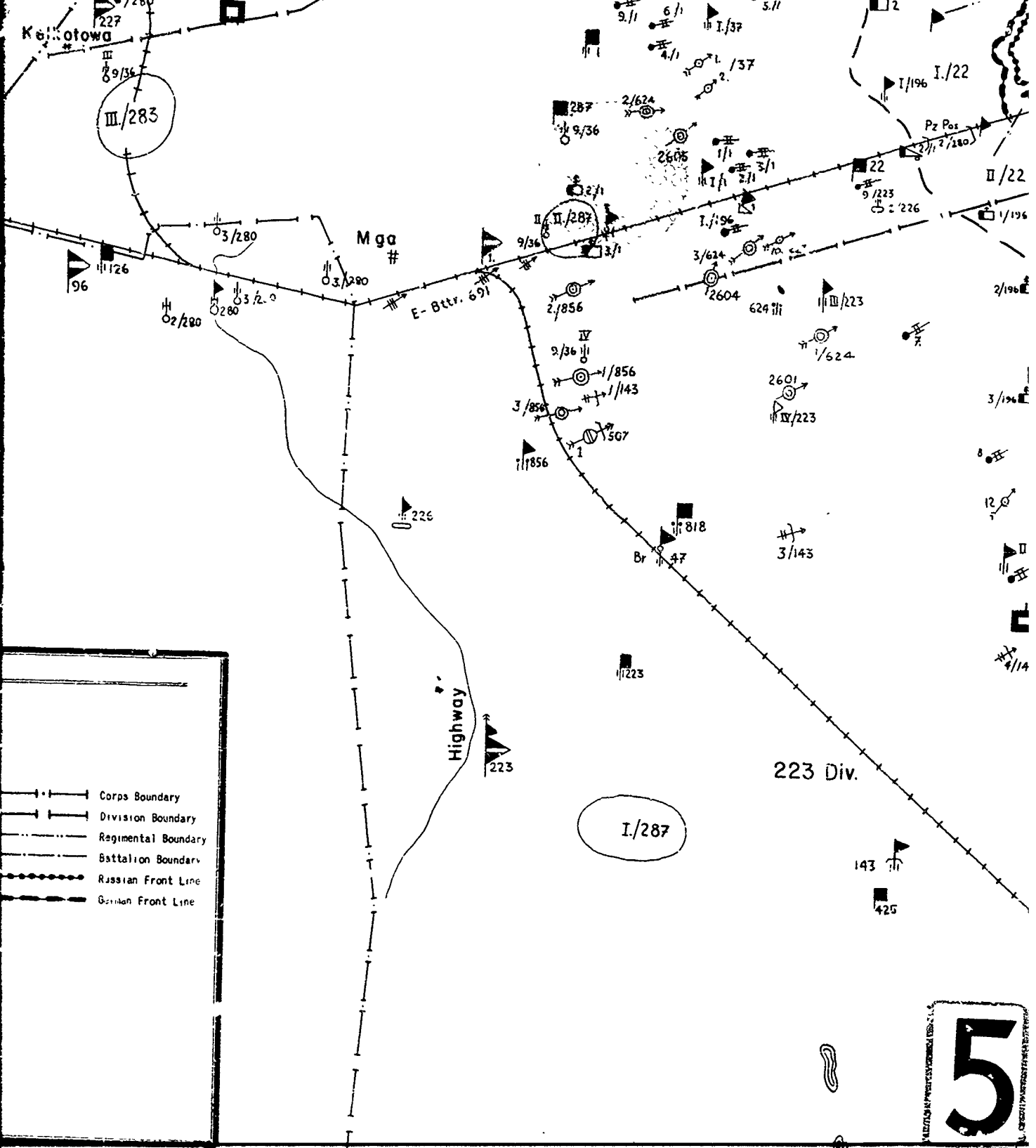
Large-scale silencing of the artillery would result if now, after the resumption of artillery operations following the use of an atomic weapon, a *second* weapon is employed (the 100 percent zones should not overlap) over nearly the same area. This second weapon should catch the artillery with its remaining personnel operating the batteries, the direction centers, et cetera without men resting in reserve

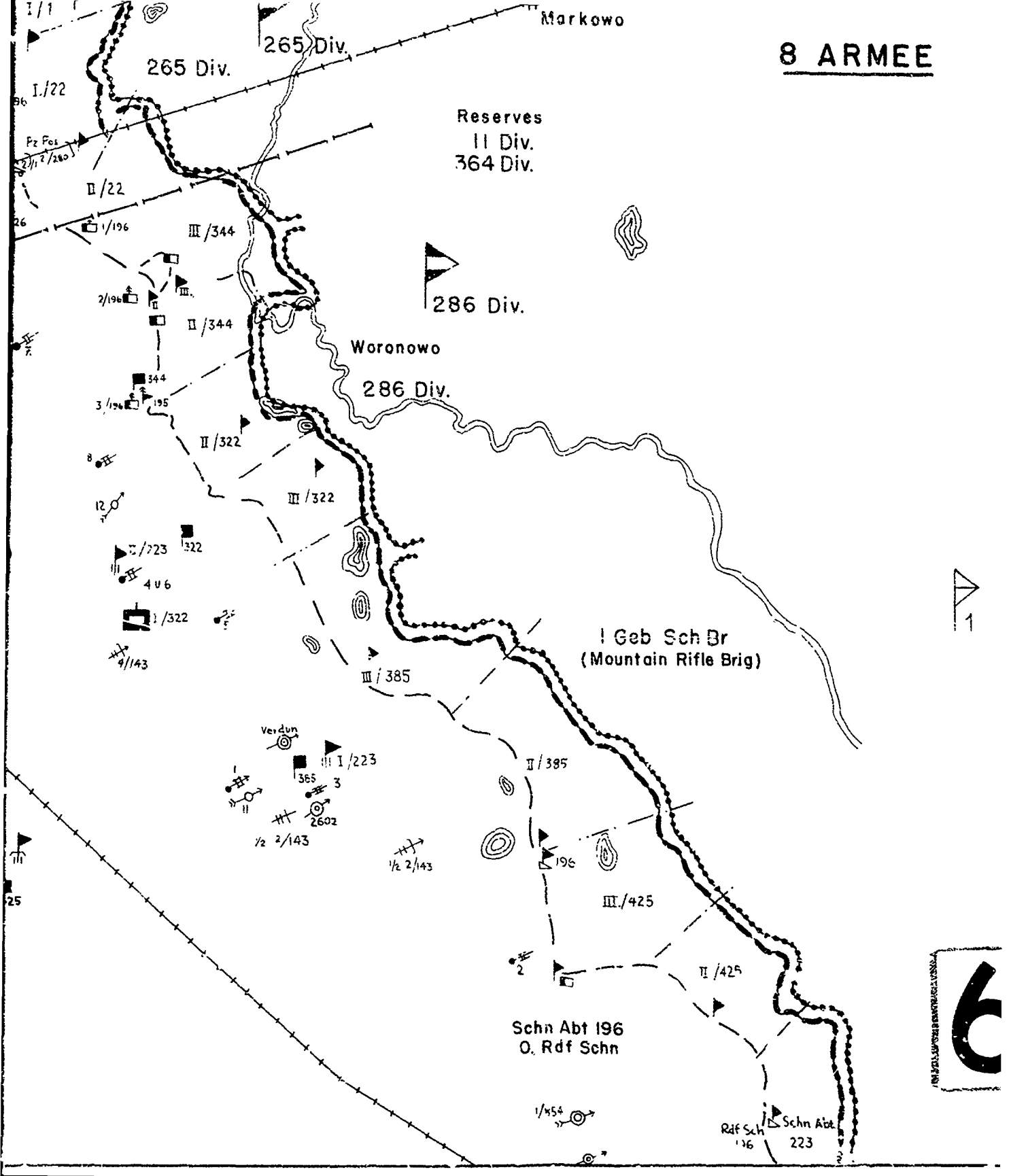

M.G. Btl. 74
67 ARMEE
Pz Jg u Art
Lehr Rat. 596
(Armored A.T. & Lt.
Arty. Regt.)
Reserves
86 Div.
91 MG
Btl.
(Machine Gun Bn.)
67
Reserves
268 Div.
45 Div.
56 Div.
86 Pz. Btl.
II
Sch Br.
(Rifle Brigade)
NEVA
RIVER
Rdf. Abt. 240
Gorodok
Dubrowka
M.G. Btl. 93
(Machine Gun Bn.)
I./401
II/401
III/401
I./207
328
II/391
I./240
III./391
I/391
I./399
III/399
II/399
II./240
III./85
III/85
227
170
284
245
Part of 3/227


55 bes Sch Br.
(Navy Infantry)
Shlusselburg
LAKE LADOGA
Schn. Abt. 227
Gnelsenay
128 Div.
256 Div.
327 Div.
314 Div.
Gantowaja Lipka
2


LAKE LADOGA
Div.
256 Div.
327 Div.
4 Div.
aja Lipka
SILAR RIVER
314
Div.
Reserves
80 Div.
372 Div.
8 (H.Q.)
Putilowo
3
8 Gef. Std.
(Command Post)


III./95
5 Geb
Kelkoto
+/910
03/280
5
502
4
1/910
2/910
XXVI
113
514
KEY
Army Hq
Corps Hq
Infantry Division Hq
Infantry Brigade Hq
Artillery Brigade Motorized
Infantry Regiment hq
Infantry Regiment Hq Motorized
Artillery Regiment Hq
Infantry Battalion Hq
Mountain infantry Battalion Hq
Artillery Battalion Hq
Self propelled Artillery Battalion Hq
Smoke Projector Battalion Hq
Engineer Battalion Hq Motorized
Engineer Battalion Hq Partly Motorized
Engineer Battalion Hq
Panzer Battalion Hq
Bicycle Battalion Hq
Infantry Battalion
Infantry Company
Infantry Platoon
Antitank Company
Engineer Company
Engineer Platoon
Sled-drawn Antitank Company
Battery 105-mm light field howitzers
Battery 88-mm antiaircraft guns
Battery mountain guns 36
Battery medium guns
Battery 150-mm heavy field howitzers
Battery 210-mm heavy field howitzers
Battery 150-mm heavy field howitzers 18
Battery 210-mm heavy field howitzers 18
Battery 305-mm heavy field howitzers 18
Battery 170-mm guns on howitzer mountings
Battery 240-mm guns (Theodor)
Battery 105-mm antiaircraft guns
Battery 105-mm light field howitzers 16
Battery 105-mm light field howitzers 18
Battery 75-mm assault guns
Battery coastal guns
Battery smoke projectors
Battery 20-mm antiaircraft guns
Battery 305-mm heavy field howitzers
Battery 170-mm coastal guns on howitzer mountings


Kolkotowa
III./283
Mga
E-Bttr. 691
Highway
223 Div.
I./287
II./287
Pz Pos
Br
Corps Boundary
Division Boundary
Regimental Boundary
Battalion Boundary
Russian Front Line
German Front Line
5


8 ARMEE
Markowo
265 Div.
265 Div.
I./22
Reserves
11 Div.
364 Div.
II/22
III/344
286 Div.
Woronowo
286 Div.
II/344
II/322
III/322
I Geb Sch Br
(Mountain Rifle Brig)
III/385
Verdun
I/223
II/385
196
III./425
II/425
Schn Abt 196
O. Rdf Schn
Rdf Sch 196
Schn Abt 223

[redacted]

These considerations lead one to estimate that at least 2 bombs per 7,000-yard frontage of artillery are required for highly effective attack against artillery; provided that these weapons are not employed simultaneously, but one-half for the first attack when the artillery is active; one-half for the second attack when the artillery resumes activity.

Since it seems likely that the decision for the use of atomic weapons must rest at a high echelon of command, the organization for the gathering of information, transmission, decision, dispatch of atomic weapon, et cetera, must be highly streamlined to allow effective use against fleeting targets. To some extent the artillery may be considered a fleeting target since it presents high vulnerability only when emplacing or firing.

Revised tactics of firing and protecting personnel would increase the requirements of atomic weapons previously stated. For instance, the enemy could keep more artillery personnel in reserve, never allowing more than one-third in vulnerable positions. Such tactics would increase the atomic weapon requirement to one per 2,500 yards of frontage, i.e., to a requirement equal to that for front line troops. This latter figure is very close to an upper limit since the 100 percent immediate casualty zones of the weapons overlap.

Dispersion of batteries in depth of greater than 5,000 yards would be required to change this requirement of weapons noticeably. This is impracticable due to present-day ranges of artillery.

The German artillery situation on the Volkhov front was studied with these qualifications in mind (see Map 28). Table XXIX lists the total number of German batteries of various types of guns operating in the Volkhov corridor. Shown for four separate bomb strike positions are the number of batteries neutralized temporarily (resting men assumed to be protected) and the number neutralized permanently, i.e., the number in which the resting men (assumed to be near the batteries) would also be expected to be immediate casualties even though protected by fox holes, et cetera.

One may assume that a total of 8 to 12 bombs would be required permanently to neutralize all the batteries listed as "temporarily" plus "permanently" neutralized.

The data is further condensed in Table XXX which gives the total number of batteries of light, medium, and heavy artillery in the corridor, together with the fraction of these permanently disabled by the first bomb over that area, and those temporarily plus permanently disabled.

These figures will not fit in the previous estimates of bombs per frontage since the front is U-shaped and the German artillery is placed in 2 main clusters and 2 minor ones.

In summary it is noted that the vulnerability of the artillery is at best about equal to that of front line troops on the defensive, except for unusual situations of front curvature, movement, et cetera. "About equal" here means within a factor of 1.5. The German artillery in the Volkhov corridor is possibly easier to neutralize than that supporting an equivalent frontage in a straighter line, since the artillery has been forced to concentrate due to the geometry of the front.

TABLE

GERMAN BATTERIES OF VARIOUS TYPES IN VOLKHOV CORRIDOR

KIND OF BATTERY	NO. OF BATTERIES IN CORRIDOR	HIT NO. 1		HIT NO. 2	
		Temporarily Neutralized	Temporarily-Plus-Permanently Neutralized	Temporarily Neutralized	Temporarily-Plus-Permanently Neutralized
20mm AA guns	11	2	2		
75mm assault guns	2	0	1		
88mm AA guns	4				
Mountain guns 36	2				
105mm how 18	41	0	10	5	14
150mm hv fld how	10			0	4
150mm hv fld how 18	8	0	4	0	1
210mm hv hi ang how	7	1	2	0	1
210mm hv hi ang how 18	11	1	5	1	4
305mm hv hi ang how 18	2			1	1
305mm hv fld how 18	1			0	1
Smoke projectors	3				
Coastal guns	3	0	1		
105mm lgt fld how	1				
Btry med guns (105?)	1			0	1
240mm Theodor guns	3	0	2		
170mm guns on how mtg	2				

TABLE XXX

FRACTION OF GERMAN FIELD ARTILLERY BATTERIES IN VOLKHOV CORRIDOR NEUTRALIZED PERMANENTLY AND PERMANENTLY-PLUS-TEMPORARILY PER BOMB HIT NO. 1

NO. OF BATTERIES	LIGHT 46		MEDIUM 28		HEAVY 27		AVERAGE	
	Permanently Neutralized	Temporarily-plus-Permanently	Permanently Neutralized	Temporarily-plus-Permanently	Permanently Neutralized	Temporarily-plus-Permanently	Permanently Neutralized	Temporarily-plus-Permanently
1st Bomb position	0	.24	0	.14	.07	.37	.023	.25
2nd Bomb position	.10	.30	0	.21	.07	.26	.057	.26
3rd Bomb position	0	.17	0	.11	.07	.19	.023	.16
4th Bomb position	.02	.09	0	.14	0	.04	.006	.09
Total Fractions of Four Bomb Positions	.12	.80	0	.60	.21	.81	.11	.76

[redacted]

XXIX
AND NUMBER NEUTRALIZED BY SELECTED BOMB HITS

NUMBER OF BATTERIES SUFFERING 25 PERCENT OR MORE IMMEDIATE CASUALTIES				TOTAL BATTERIES NEUTRALIZED		TOTAL BATTERIES REMAINING ACTIVE	
Hit No 3		Hit No. 4					
Temporarily Neutralized	Temporarily-Plus-Permanently Neutralized	Temporarily Neutralized	Temporarily-Plus-Permanently Neutralized	Temporarily Neutralized	Temporarily-Plus-Permanently Neutralized	Temporarily Neutralized	Temporarily-Plus-Permanently Neutralized
0	2	0	1	2	5	9	6
				0	1	2	1
0	1	0	1	0	2	4	2
0	1	1	1	1	2	1	0
0	7	0	3	5	34	36	7
0	2	0	3	0	9	10	1
0	1	0	1	0	7	8	1
0	2	0	1	1	6	5	1
0	1			2	10	9	1
1	1			2	2	0	0
					1	1	0
					0	3	3
					1	3	2
					0	1	1
					1	1	0
					2	3	1
0	1				1	2	1

[redacted]

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ENCLOSURE F

PROBABLE EFFECT OF ATOMIC WEAPONS ON US FIRST ARMY IN WORLD WAR II

by

Solomon H. Turkel and Alvin D. Cook

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PROBABLE EFFECT OF ATOMIC WEAPONS ON US FIRST ARMY IN WORLD WAR II

INTRODUCTION

This report will consider the probable effect of air burst atomic bombs on the operations of the US First Army in Europe in World War II. The operations from the beachhead to contact with the Soviets will first be outlined and finally some specific actions will be analyzed. It is emphasized that while it is possible with suitable assumptions to approximate the effect of the bomb on combat personnel, it has not been found profitable to attempt to determine the amount of damage to military equipment or to lines of communication. Techniques will be developed to expand the analysis to include other than effects on personnel. In the meantime, the following analysis is presented as a first approximation to a solution.

FIRST ARMY OPERATIONS IN EUROPE

On 1 March 1945 at 2000 hours the First Army, massed and prepared for an attack against Cologne, had begun to move forward on a 28-mile front. Of the 17 miles V Corps held of this front, the 69th Div was responsible for 5,000 yards. (See Table XXXI for First Army Report of Operations, and Table XXXII for Strength of Corps.)

The 9,000 men in the 3 regiments of the 69th Div (i.e., 271st, 272nd, and 273rd Regt) were within 2,500 yards of the front line. These situations are illustrated in Maps 29, 30, and 31. The 272nd Regt of the 69th Div was in reserve south of the 69th Div in the 106th Div area.

Position and strength of division artillery is uncertain. It is assumed to consist of 4 battalions of 500 men each, and is known to be supported by 2 battalions of 500 men each, and one heavy howitzer battery of about 150 men from V Corps. All 6 of these battalions are located 3–6 miles from the front line, 3 battalions assumed to be within the 273rd Regimental area and 3 within the 271st. The heavy howitzer battery is probably further than 6 miles from the front line.

EFFECT OF ATOMIC BOMBING ON FIRST ARMY

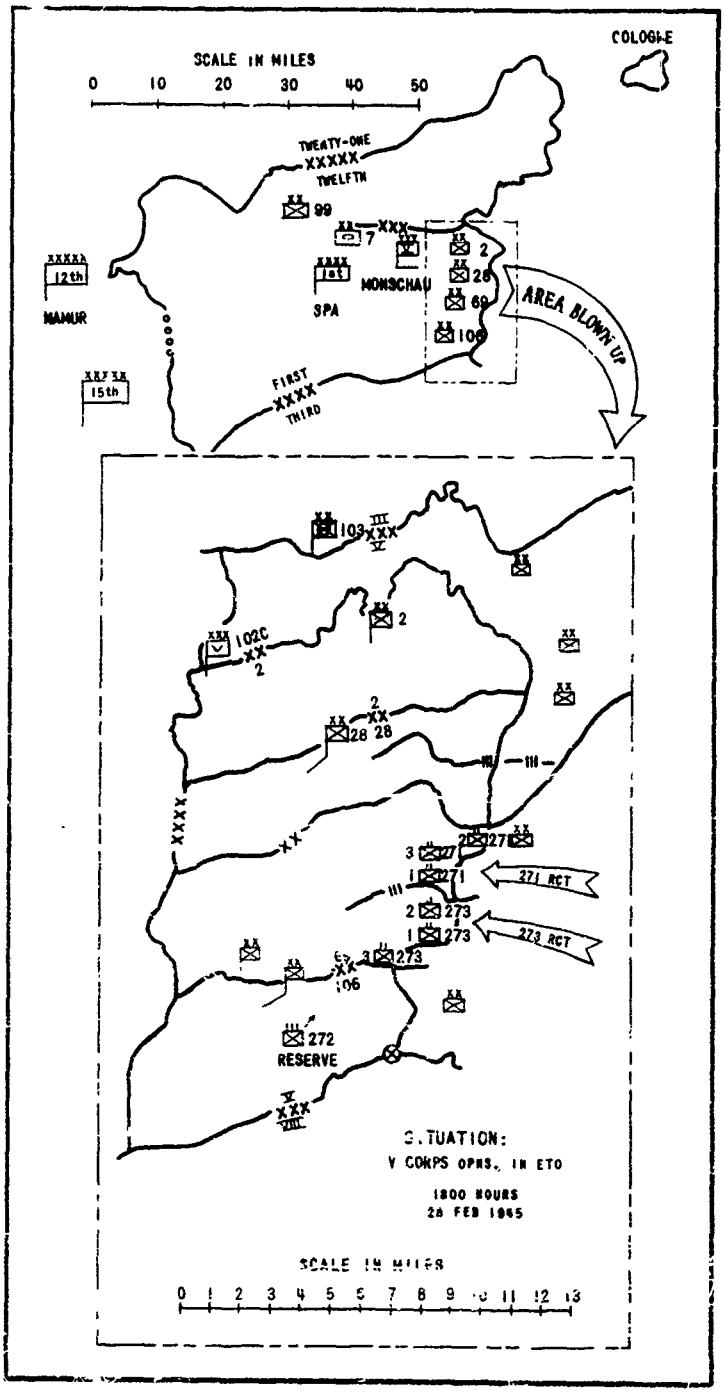
Using Map 30 showing the position of the 273rd Regt, the effect of bursting a 20 KT atomic bomb at each of the aiming positions numbered in shaded areas on the map is considered.

The actual distance in yards of all the troops within the radius of the bomb's effect is measured and the resulting percentage of deaths and incapacitations is read off from Figures 25 and 27. Incapacitation means an injury sufficient to require hospitalization or first aid, the soldier being removed from active participation in the battle.

In Table XXXIII the results of these measurements are tabulated for the 273rd Regiment.

Similarly, using Map 31, the effects of dropping an atomic bomb at various places within the area of the 271st Regt are studied and the results presented in Table XXXIV. For a bomb dropped close to the line *between* the 273rd and 271st Regt (see Map 31, aiming point 9), the results can be summarized in Table XXXV.

A study of Figures 28, 29, 30, and 31, shows that the average frontage of a division in the First Army ranged from 1.71 miles in defensive operations (12–19 divisions in action). On the average, 1 20 KT atomic bomb will effectively stop an offensive operation of a division, if the men are wearing ordinary clothing, and 2 bombs will stop the offensive if the men are wearing special uniforms. If the frontage is smaller than average, 1 atomic bomb may be sufficient to eliminate a division even though the men are wearing special clothing.



Map 29.—Position of US First Army 1 March 1945, 1200 Hours

TABLE XXXI
FIRST US ARMY, REPORT OF OPERATIONS[1]

DATE	SITUATION	OPERATION
1944		
15 May–1 Aug		Amphibious Offensive
	Mounting of Operation "*Neptune*"	Amphibious Operations
6 June	Operations on *Omaha* and *Utah* Beaches	Amphibious
7–10 June	Establishment of *Beachhead*	Amphibious
	Campaign to Capture *Cherbourg*	Offensive Operations
	Cutting the *Peninsula* and the	Offensive
	advance Capture of *Cherbourg*	Offensive
25 July–1 Aug		Pursuit
	Operation "*Cobra*"	Pursuit
	Success of Decisive *Breakthrough* operation	Pursuit
1 Aug–12 Sep		Pursuit
	Exploitation of *St. Lo Breakthrough*	Pursuit
1–12 Aug	The Drive South	Pursuit
	Mortain counterattack	Pursuit
	Checking the Blow	Pursuit
13–19 Aug	*Falaise-Argentan* Gap	Pursuit
	Closing the Gap	Pursuit
19–26 Aug	Drive to the *Seine*	Pursuit
	Capture of *Elbeuf*	Pursuit
	Capture of *Paris*	Pursuit
	Preparations for *Exploitation*	Pursuit
27 Aug–3 Sep	Battle of *Northern France*	Pursuit
	Drive to the North	Pursuit
	Change of Direction to the East	Pursuit
4–12 Sep	Push to the *Siegfried Line*	Pursuit
13 Sep–15 Dec	Battle of Germany	Offensive
13 Sep–1 Oct	Consolidation	Offensive
2–21 Oct	*Aachen* offensive	Offensive
	Capture of *Aachen*	
22 Oct–15 Nov	Preparation for a new offensive	Offensive
	Attack toward *Schmidt*	Offensive
16 Nov–15 Dec	Drive to *Roer River*	Offensive
13–15 Dec	*Roer Dams* Offensive	Offensive
16 Dec–22 Feb 1945	*German Counteroffensive* and Drive to Roer River	Defense
16 Dec–2 Jan 1945	German *Counteroffensive*	Defense
1945		
3 Jan–27 Jan	Allied *Counterattack*	(Counterattack)
28 Jan–22 Feb	Drive to Roer River	Offense
23 Feb–28 Feb	Crossing the Roer River	Offense
	Drive to the *Erft River*	Offense
1–24 Mar	Crossing the *Rhine*	Offense
	Advance across the *Erft River* to the *Rhine*	Offense
7 Mar	Capture of *Remagen Bridge*	Offense
8–24 Mar	Build-up of *Bridgehead*	Offense
25 Mar–18 Apr	Exploitation of *Remagen Bridgehead*	Pursuit
	Encirclement of German Army Group B	Pursuit
6–18 Apr	Drive to *East*	Pursuit
	Clearing *Ruhr Pocket*	Pursuit
19 Apr–8 May	*Final Operations*	Offensive
19–24 Apr	*Consolidation* on *Mulde River*	Offensive
25 Apr–8 May	*Contact* with the Soviet Army	Offensive

[1] First Army had 2–4 Corps (av. 3); and 5–19 Divisions (av. 12). Average First Army front 101.49 miles (19.8 min—287 max).

TABLE XXXII

V CORPS OF FIRST ARMY IN GERMANY 28 FEBRUARY 1945

	OFFICERS	ENLISTED MEN
69th Division		
Assigned Units		
271 Inf Regt.	158	2,736
272 Inf Regt.	161	2,991
273 Inf Regt.	159	2,940
69th Div Artillery		
269 Engr Combat Bn		
369 Med Bn		
HQ Spec Troops		
69 MP Platoon		
69 Recon Troops (meczd)		
69 QM Co		
569 Signal Co		
769 Ordnance QM Co		
HQ and HQ Co 69th Inf Div		
Attached		
661 TD Bn		
Supporting Units		
406 FA Gp		
HQ and HQ Btry	18	76
4186 FA Bn (155mm howitzer—tractor, drawn)	30	471
941 FA Bn (4.5-inch gun—tractor, drawn)		
B Btry—552nd FA Bn (240 mm howitzer—tractor, drawn)		
467 AAA Auto Wpns Bn (SP)—A, B, C, D Btrys using M-16's and M-15's	36	659
	(562)	(9,864)
69th Division Total	804	12,983
28th Division	743	13,140
2nd Division	868	13,264
106th Division	327	5,666
7th Armored Division (Reserve)	714	10,102
	3,556	55,155
V Corps Troops	25,400 officers and enlisted men	
Total Strength V Corps	85,000 officers and enlisted men	

The V Corps on 1 March 1945 had 4 infantry divisions and 1 armored reserve division in the field. It contained about 85,000 men and held a 16-mile front. Atomic bombs have little effect on tanks and personnel inside the tank. The only hazard to men inside tanks is that from gamma radiation, and since these effects are in general delayed, the immediate tactical situation will not be affected. Since 1 bomb will effectively stop the offensive operation of a division, 4 bombs would destroy the V Corps on 1 March 1945 if the men were wearing ordinary clothing. If the men were wearing protective clothing, 8 bombs or less would be necessary to destroy the corps.

Figures 28–31 show that the corps' frontage varied from a minimum of 6 miles to a maximum of 190 miles for various types of operation. Since the lethality of the bomb depends on the distance from burst a corps that was widely dispersed would require many more bombs to knock it out. Thus, it is obvious that the time picked to drop an atomic bomb is of paramount importance.

The First Army, of which the V Corps was a part, had from 2 to 4 corps (average 3) and between 5 to 19 divisions (average 12) from 15 May 1944 to 8 May 1945. The army frontage ranged from a minimum of 19.8 miles to a maximum of 287 miles. On 1 March 1945, there were two corps in the First Army and the frontage was about 32 miles. If the men were in ordinary clothing 8 bombs or less would have been required to knock out the First Army, 16 bombs or less being required if the men wore protective clothing.

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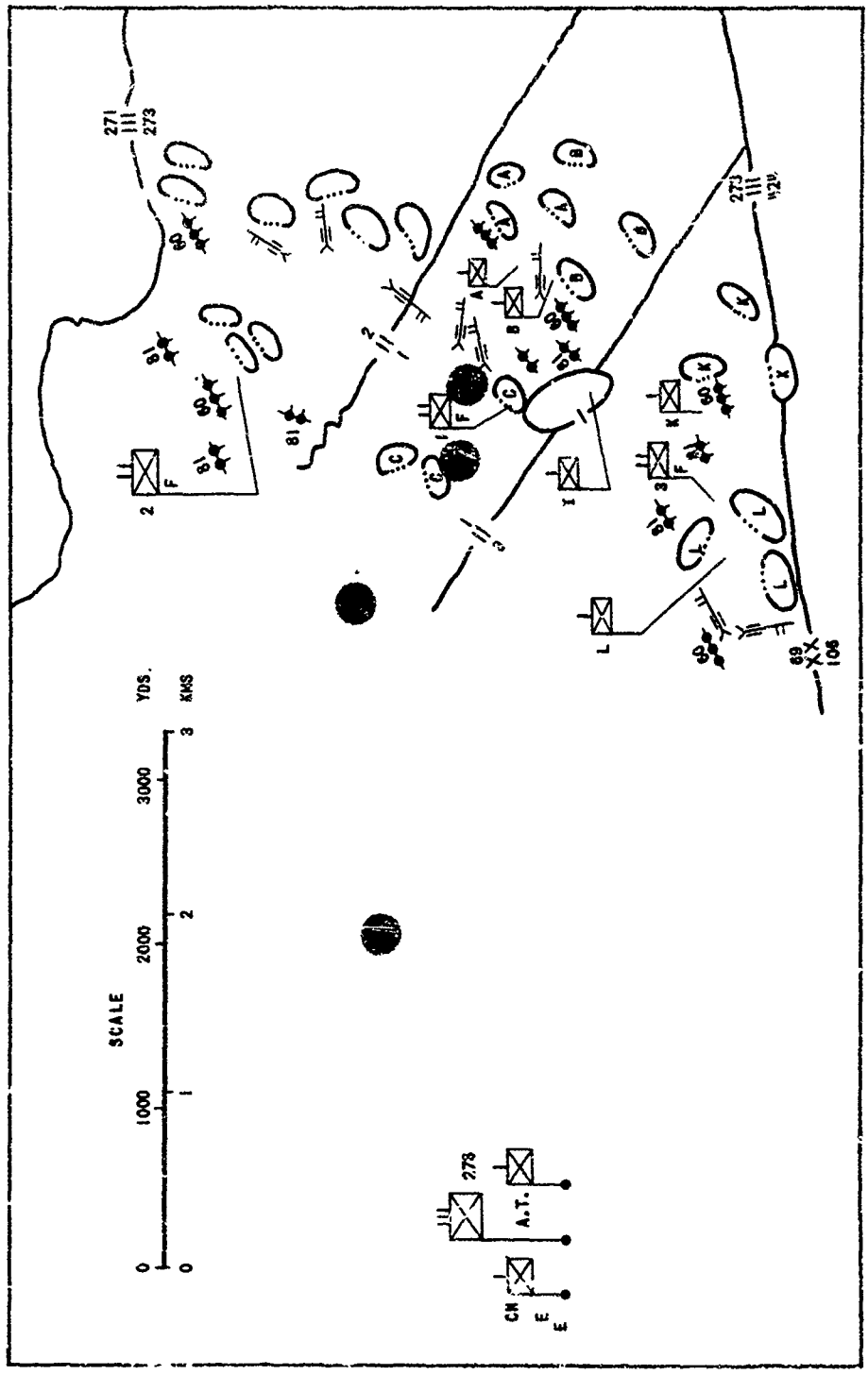
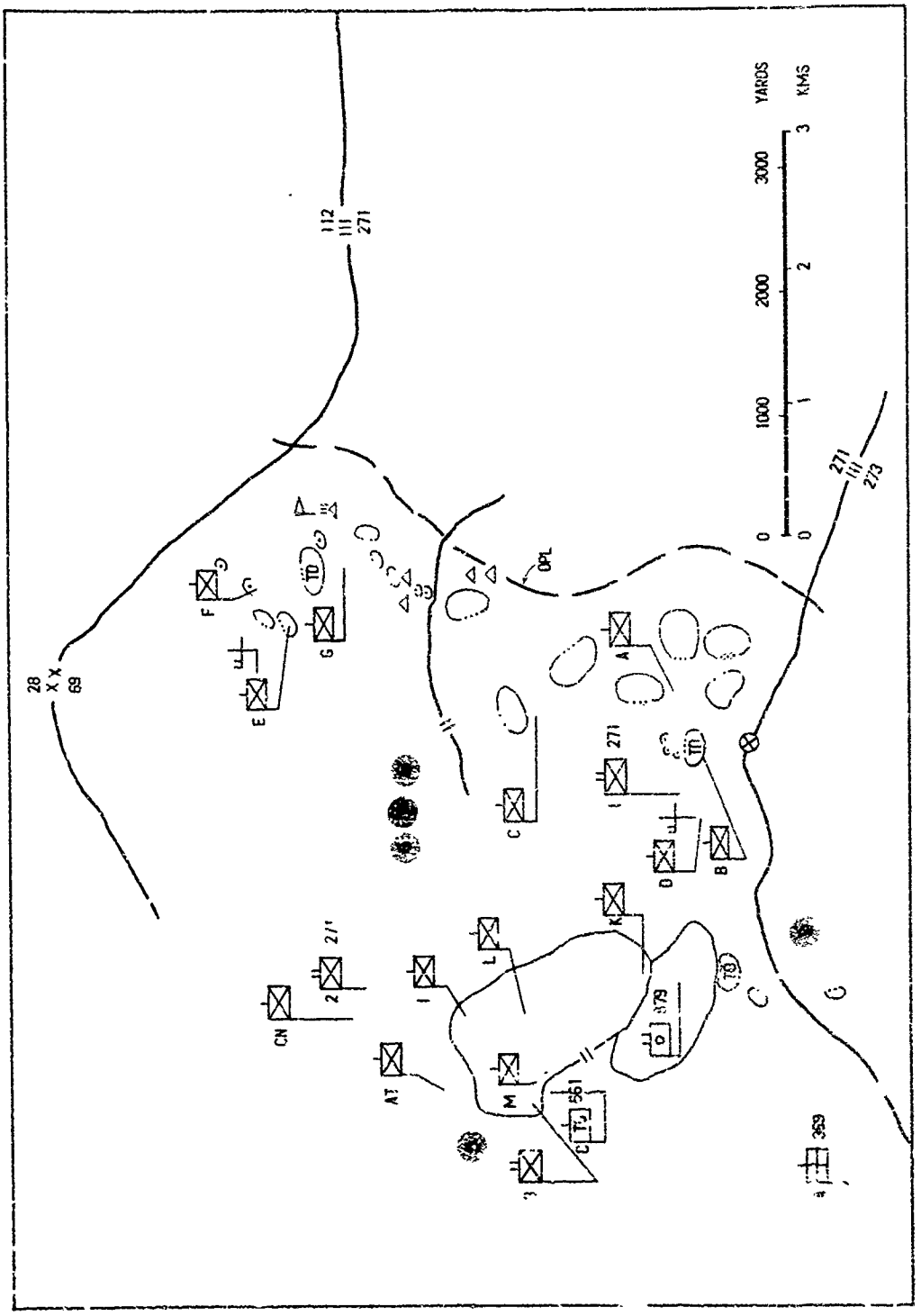


Map 30.—Position of 273rd Regiment on 1 March 1945 at 2000 Hours



Map 31.—Position of 271st Regiment on 1 March 1945

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TABLE XXXIII

EFFECTS OF GERMAN USE OF ATOMIC BOMBS AGAINST THE 273RD REGIMENT, 69TH DIVISION, V CORPS, FIRST ARMY, 1 MARCH 1945, 2000 HOURS

EXAMPLE	AIMING POINT	TARGET	ASSUMPTIONS	EFFECTS
I	1	Artillery	1. U.S. troops and German troops *dug in.* 2. Artillery men in open. 3. All men in ordinary uniform.	1. Three artillery battalions of the 273rd, several command posts, and some supporting units almost completely knocked out (approx. 1,000 dead, 800 incapacitated). 2. Half of one artillery battalion in 271st Regimental area, and part of one artillery battalion in 424th Regimental area of 106th Division, plus parts of supporting units, knocked out (approx. 200 dead, 400 incapacitated). 3. No front line troops affected.
Summary: Approximately 1,200 killed and 1,200 incapacitated. Artillery effectively eliminated and any offensive action of this regiment stopped. All effects are on personnel, little damage occurring to guns.				
II	1	Artillery	1. U.S. troops in *open*, German troops *dug in.* 2. Artillery men in open. 3. All men in ordinary uniform.	1. Effects on artillery the same as effects 1 and 2, Example I. 2. Approx 600 front line troops die, and 1,200 incapacitated.
Summary Approximately 1,800 killed and 2,400 incapacitated. Artillery effectively eliminated. More than half of all front line troops in Reg. area are out of action. Artillery fire control and optical apparatus located at observation posts may be damaged.				
III	1	Artillery	1. U.S. and German troops *dug in.* 2. Artillery men in open, wear *special uniform.* 3. All front line troops in ordinary uniform.	1. About two-thirds of artillery strength of 273rd Regt. knocked out (approx. 400 dead, 600 incapacitated). 2. Little or none of artillery in adjacent Regimental areas affected. 3. No front line troops affected.
Summary Approximately 400 killed and 600 incapacitated. Two-thirds loss of artillery in Regimental area effectively eliminates the Regiment from offensive action. If artillery men can get some shielding such as metal shields on gun positions, and/or some shielding from ground burial, effects on artillery will be greatly reduced.				
IV	2	Troops	1. U.S. troops in *open*, German troops *dug in.* 2. Artillery men in open. 3. All men in ordinary uniform. 4. German troops at least 2,000 yds. from ground zero	1. Approx. 2,900 front line troops of the 273rd Regt. out of action (about 2,300 dead, 700 incapacitated). 2. Close to 10 percent of 271st Regiment personnel incapacitated (350 men) and 10 percent of 424th Regiment personnel incapacitated (350 men). 3. About 80 percent of all artillery personnel in 273rd Regiment area knocked out (500 dead, 700 incapacitated). 4. About 75 percent of personnel of one battalion of artillery in 271st Regiment area knocked out, plus other supporting units and CP, plus about 40 percent of one service company in 271st Regiment (approx. 150 dead, 350 incapacitated). 5. Approx. 40 percent of one artillery battalion in 424th Regiment area knocked out (50 dead, 150 incapacitated)
Summary Approximately 2,900 killed and 2,600 incapacitated. Troops and the troops are out in the open the effects will be overwhelming and completely wipe out the offensive of the Regiment, at the same time doing considerable damage to adjacent units				

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TABLE 2.XXIII (*Continued*)

EXAMPLE	AIMING POINT	TARGET	ASSUMPTIONS	EFFECTS
V	3	Front Line Troops	1. U.S. and German troops *dug in*. 2. Artillery men in open. 3. All men in ordinary uniform. 4. German troops at least 2,000 yds. from ground zero.	1. Approx. 900 front line troops of the 273rd Regt. out of action (200 dead, 700 incapacitated) 2. About one and one-half artillery battalions knocked out (400 dead, 350 incapacitated). 3. About 25 percent of one artillery battalion in the 271st Regimental area and 25 percent of one artillery battalion in the 424th Regiment area knocked out (100 dead, 200 incapacitated).
Summary: Approximately 700 killed and 1,250 incapacitated. These effects should be enough to stop the offensive of the Regiment.				
VI	4	Front Line Troops	1. U.S. troops in open, German troops *dug in*, both in special uniform. 2. Artillery men in open in ordinary uniform. 3. German troops at least 1,650 yds. from ground zero.	1. About 500 front line troops of the 273rd Regt. dead, 1,000 incapacitated. 2. One and one-half artillery battalions knocked out (300 dead, 450 incapacitated). 3. About 15 percent of each artillery battalion north and south of 273rd Regiment out of action (60 dead, 120 incapacitated).
Summary: Approximately 860 killed and 1,570 incapacitated. Artillery effectively knocked out and infantry seriously lost. Offensive will be stopped.				

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TABLE XXXIV

EFFECTS OF GERMAN USE OF ATOMIC BOMBS AGAINST THE 271ST REGIMENT, 69TH DIVISION, V CORPS, FIRST ARMY, 1 MARCH 1945, 2000 HOURS

EXAMPLE	AIMING POINT	TARGET	ASSUMPTIONS	EFFECTS
VII	5	Artillery	1. Same as in Example I.	1. Three artillery battalions of 271st Regt., several command posts and supporting units knocked out (1,300 dead, 300 incapacitated). 2. Half of one artillery battalion in 273rd Regiment and 28th Division knocked out (approx. 200 dead, 400 incapacitated). 3. No front line troops affected.
Summary: Approximately 1,500 killed and 1,000 incapacitated. Results same as Example I.				
VIII	5	Artillery	1. Same as in Example II	1. Same as in Example VII above for artillery. 2. Approx. 600 front line troops dead, 1,200 incapacitated.
Summary: Approximately 1,900 killed and 1,800 incapacitated. Results the same as Example II.				
IX	5	Artillery	1. Same as in Example III.	1. Same as in Example 3 for artillery and front line troops.
Summary: Same as Example III.				
X	6	Front Line Troops	1. Same as in Example IV.	1. Approx. 2,900 front line troops of the 271st Regt. out of action (2,200 dead, 700 incapacitated). 2. About 10 percent of personnel in 273rd Regt. and 10 percent of one regiment of 28th Division out of action (200 dead, 450 incapacitated). 3. 75 percent of artillery personnel out of action (500 dead, 700 incapacitated). 4. 15 percent of one 273rd Regiment artillery battalion out of action and half of one 28th Division artillery battalion (100 dead, 225 incapacitated).
Summary: Approximately 3,000 killed and 2,075 incapacitated. Results same as in Example IV.				
XI	7	Front Line Troops	1. Same as in Example V.	1. Approx. 900 front line troops of the 271st Regt. out of action (200 dead, 700 incapacitated). 2. Two artillery battalions knocked out (300 dead, 700 incapacitated). 3. 10 percent of the 28th Division artillery out of action (50 dead, 100 incapacitated).
Summary: Approximately 550 killed and 1,500 incapacitated. Results same as in Example V.				
XII	8	Front Line Troops	1. Same as in Example VI.	1. Approx. 1,200 front line troops of the 271st Regt. out of action (400 dead, 800 incapacitated). 2. 60 percent of the three artillery battalions in the Regimental area knocked out (300 dead, 650 incapacitated). 3. 30 percent of one artillery battalion of 28th Division knocked out (50 dead, 130 incapacitated).
Summary: Approximately 750 killed and 1,580 incapacitated. Serious damage to both artillery and infantry. Offensive action of the Regiment is stopped.				

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TABLE XXXV

EFFECTS OF GERMAN USE OF ATOMIC BOMB AGAINST THE 69TH DIVISION, V CORPS, FIRST ARMY, 1 MARCH 1945, 2000 HOURS

EXAMPLE	AIMING POINT	TARGET	ASSUMPTIONS	EFFECTS
XIII	9	69th Div.	1. U.S. troops in open, German troop *dug in.* 2. Artillery men in open. 3. All men in *ordinary uniform.* 4. German troops at least 2,000 yds. from ground zero.	1. Approx. 5 artillery bns. knocked out (about 1,200 dead, 1,600 incapacitated). 2. 6,000 front line troops out of action (2,000 dead, 4,000 incapacitated).
Summary: Approximately 3,200 killed and 5,600 incapacitated. Almost complete elimination of div. art. and front line troops. Div. offensive stopped.				
XIV	9	69th Div.	1. U.S. troops *dug in* and German troops *dug in.* 2. Artillery in open. 3. All men in *ordinary uniform.* 4. German troops at least 2,000 yds. from ground zero.	1. Effects on artillery same as in Example XIII (1,200 dead, 1,600 incapacitated). 2. 1,000 front line troops out of action (400 dead, 600 incapacitated).
Summary: Approximately 1,600 dead and 2,200 incapacitated. Despite the lower losses in front line troops as compared with Example XIII, the elimination of the division artillery will remove the division from effective offensive action.				
XVI	1	69th Div. Artillery	1. U.S. troops *dug in* and German troops *dug in.* 2. Artillery in open. 3. All men in *special uniform.* 4. German troops at least 1,650 yds. from ground zero.	1. About 2 bns. of the artillery within the 273rd Regt. area knocked out (approx. 400 dead and 600 incap.). 2. About 2 bns. of the artillery within the 271st Regt. area knocked out (approx. 400 dead and 600 incap.).
	and			
	5	69th Div. Artillery	Same assumption as in Aiming Pt. 1 above.	3 No front line troops affected.
Summary: Approximately 800 dead and 1,200 incapacitated. The two bombs will definitely knock out the division offensive. One of these bombs may prove sufficient to knock out the division's offensive since it will neutralize one-third of the division's artillery.				
XVI	4	69th Div. Front Line Troops	1 U.S. troops in open. German troops dug in. 2. Artillery in open. 3. All men in *special uniform.* 4. German troops at least 1,650 yds. from ground zero.	1. About 500 front line troops dead and 1,000 incapacitated in 273rd Regt. 2. About 400 front line troops dead and 800 incapacitated.
	and			
	8		Same assumptions as in Aiming Point 4 above	
Summary: Approximately 900 killed and 1,800 incapacitated. This would stop the offensive of the Division.				

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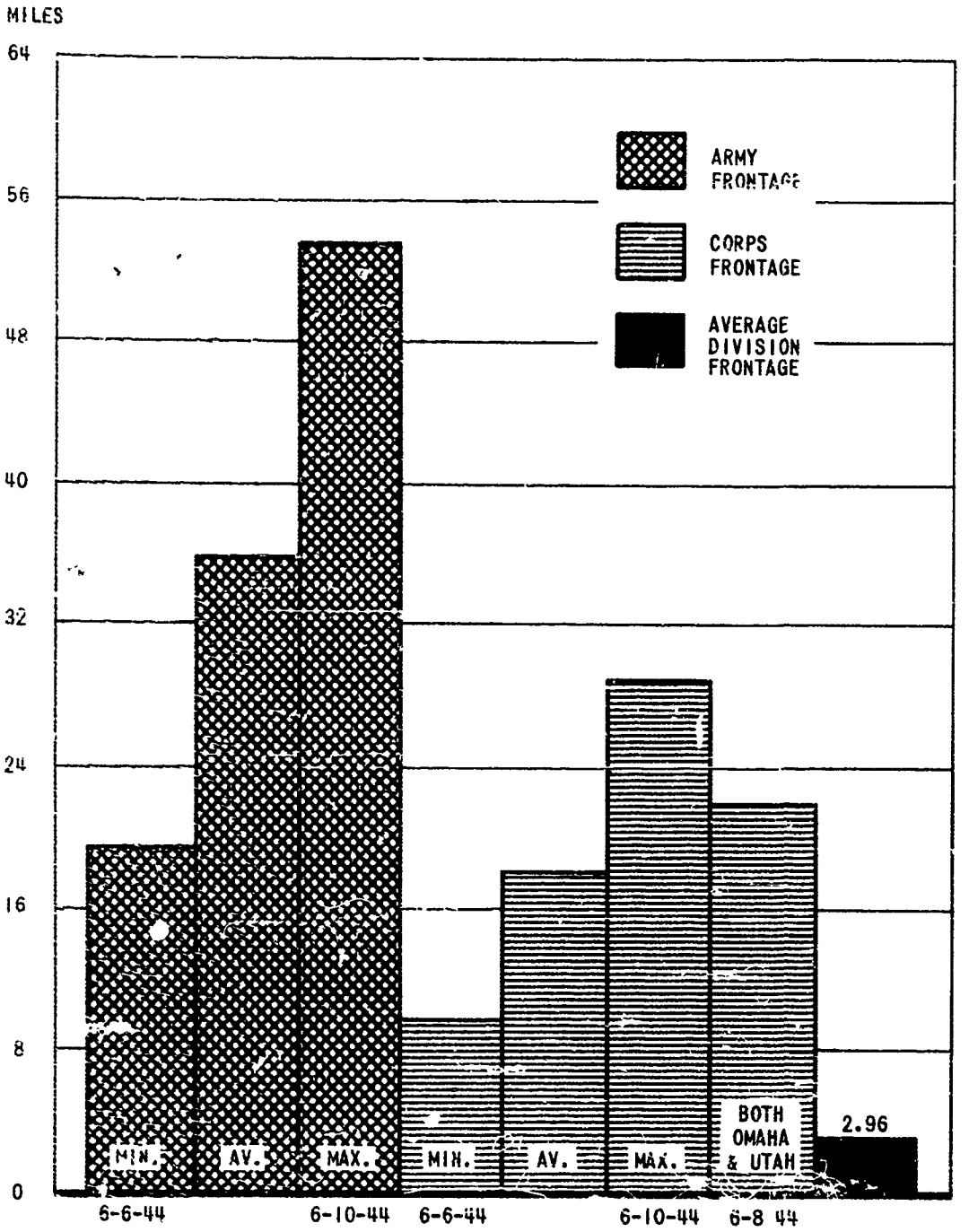

Figure 28.—I Army Frontage, Amphibious Assault, 6–10 June 1944. I Army 2 Corps. 5–9 Divisions (Av. 6 Divisions)

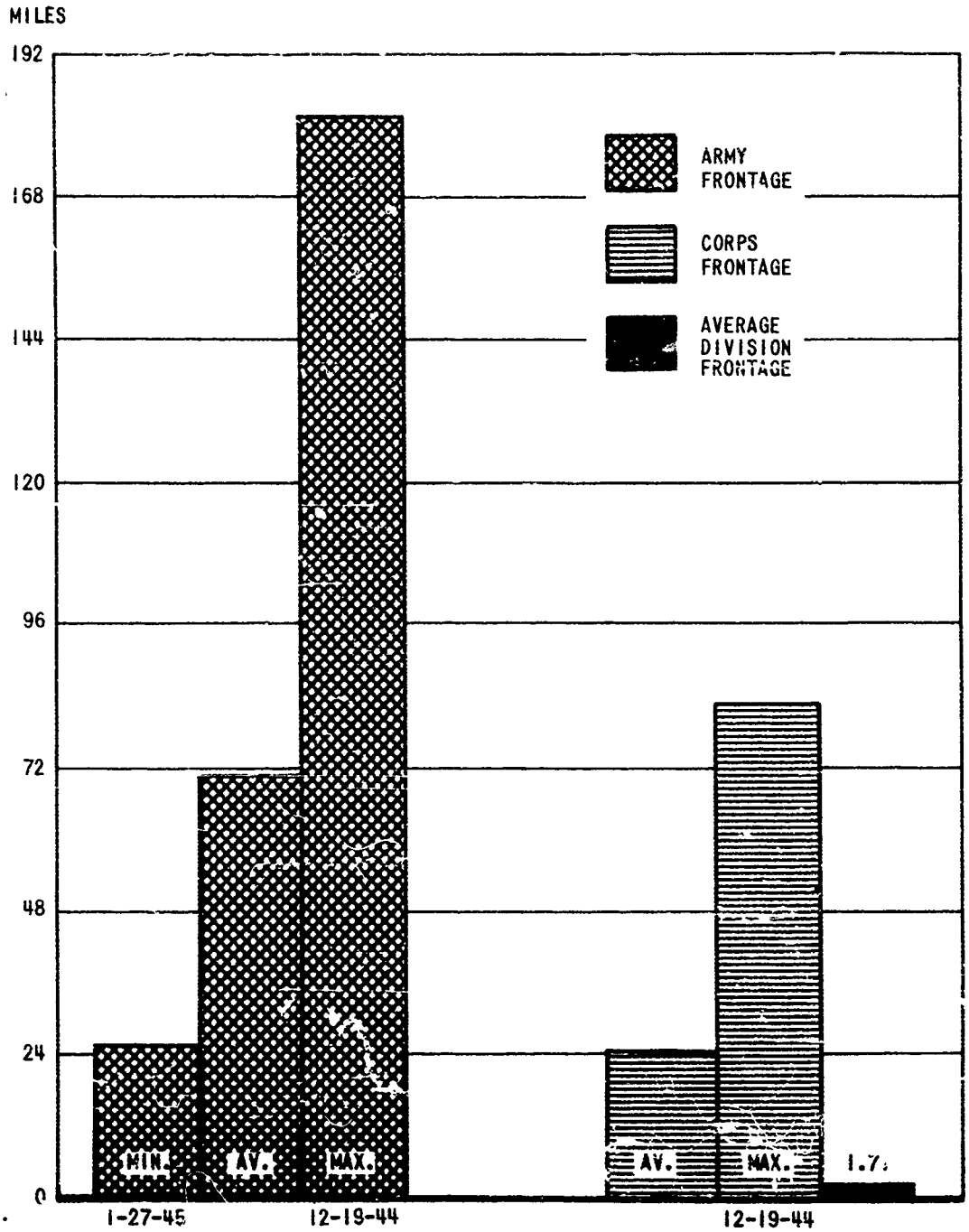

Figure 29.—I Army Frontages, Defensive Operations, 16 December 1944–27 January 1945, (9 January–27 January 1945. Counterattack phase by I Army) I Army. 3–4 Corps (Av. 3 Corps). 12–19 Divisions (Av. 14 Divisions)

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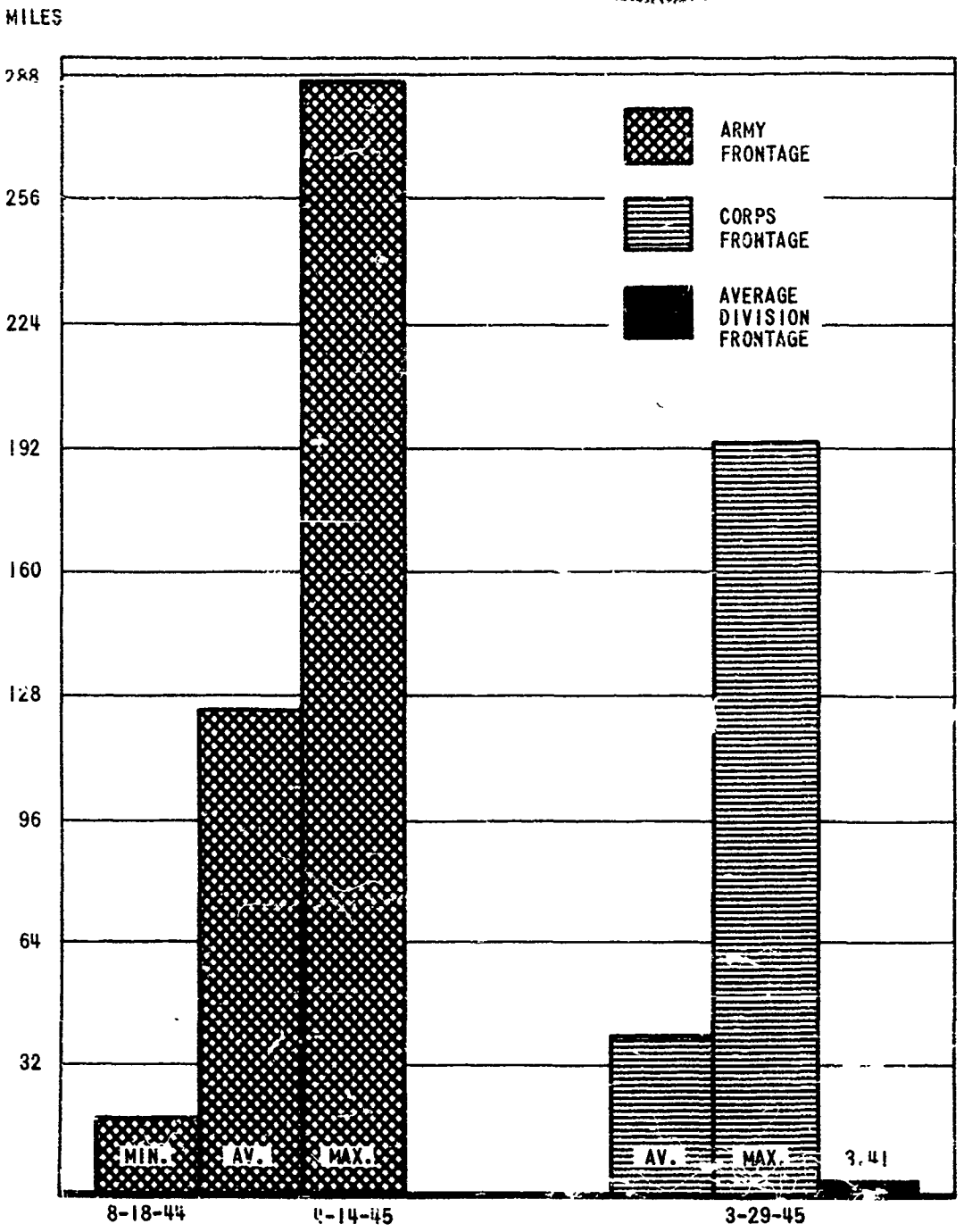

Figure 30.—I Army Frontages, Pursuit Operations, "Operation Cobra" 25 July-12 September 1944; Breakout from Remagen Bridgehead to Mulde River, (25 March-18 April 1945) I Army. 3-4 Corps (Av. 3 Corps). 8-17 Divisions (Av. 12 Divisions)

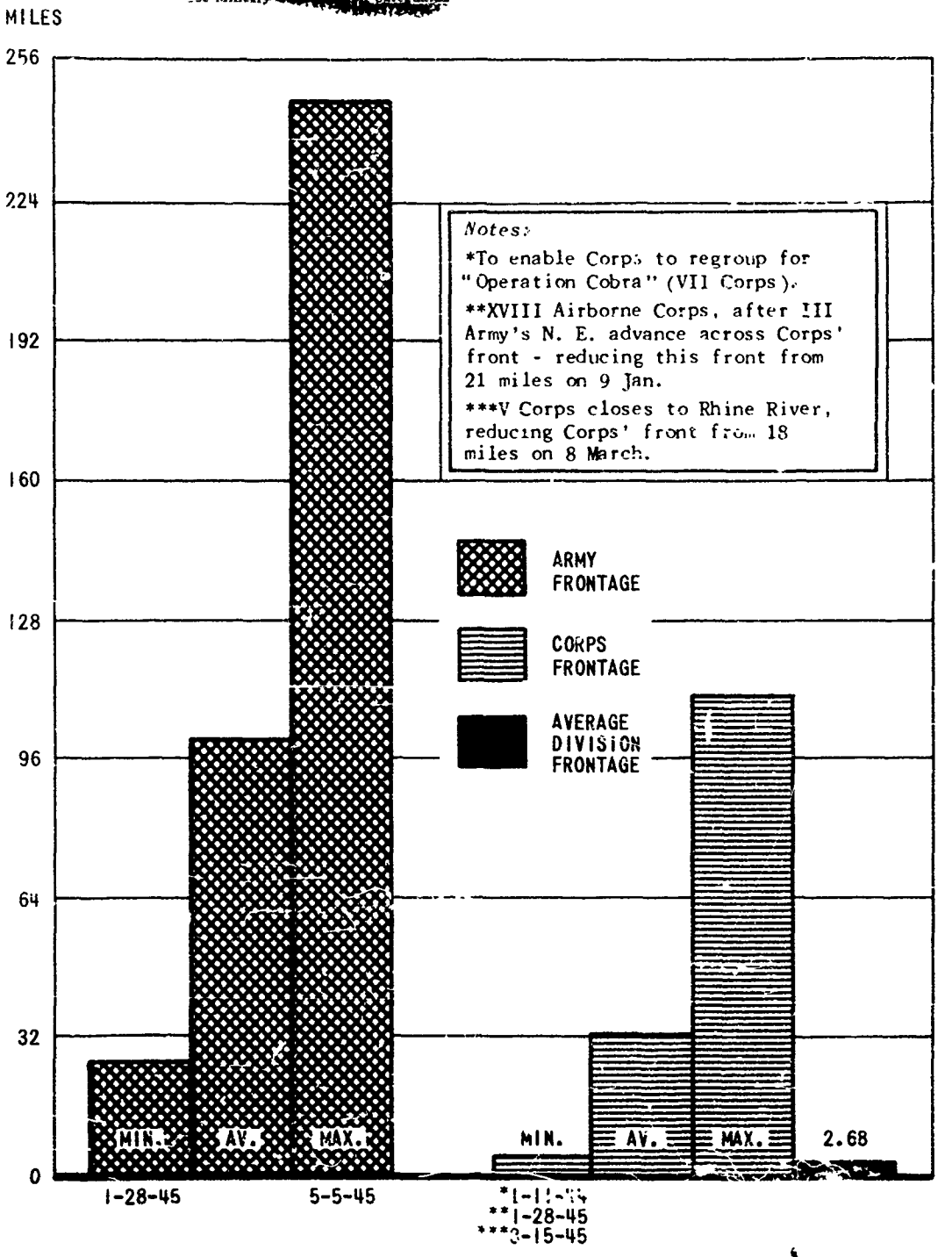

Figure 31.—I Army Frontages, Offensive Operations, 11 June 1944–24 July 1944, 13 September 1944–15 December 1944, 28 January 1945–24 March 1945, 19 April 1945–8 May 1945, I Army: 2–4 Corps (Av. 3). 8–16 Divisions (Av. 12)

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CONCLUSIONS

One atomic bomb properly placed can effectively knock out large amounts of the artillery personnel in the regimental areas and many front line troops, eliminating the offensive action of the regiment.

One bomb properly placed can remove a sufficient number of artillery and front line personnel of a division in ordinary clothing from action to effectively destroy the offensive power of the division. If the men are in special uniform and dug in, it will probably take about 2 bombs to achieve the same result.

Against a corps holding a front line of average length, 1 bomb per division will be required to eliminate the offensive power of the corps if the men are in ordinary clothing and 2 bombs per division if they are wearing special clothing.

The number of bombs required to destroy the offensive power of an army depends on the extent of frontage, the clothing worn by the men and whether or not they were dug in. Less than a dozen bombs would have destroyed the usefulness of the First Army on 1 March 1945.

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ENCLOSURE G

A COMPARATIVE STUDY OF THE CASUALTIES FROM A 20 KT AIR BURST OF AN ATOMIC BOMB OVER US AND USSR TROOPS DEPLOYED FOR ASSAULT ACCORDING TO STANDARD OPERATING PROCEDURE

by

Solomon H. Turkel and Alvin D. Coox

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A COMPARATIVE STUDY OF THE CASUALTIES FROM A 20 KT AIR BURST OF AN ATOMIC BOMB OVER US AND USSR TROOPS DEPLOYED FOR ASSAULT ACCORDING TO STANDARD OPERATING PROCEDURE

PROBLEM

To estimate casualties to US and USSR infantry divisions deployed for assault according to standard operating procedure, from an air burst of a 20 KT atomic bomb.

FACTS

Standard operating procedures for the deployment of infantry in assault are available for both US and USSR armies. Defensive deployment is not considered in this study.

Estimates of casualty probabilities as functions of distance from ground zero for a 20 KT bomb exploded at a height of 600 yards are available from Annex 1 of this appendix.

DISCUSSION

The deployments assumed are shown in Figures 32 and 33. The terrain is assumed to be level and without natural shelter.

The T/O for US infantry is taken from FM 30–10 and the depths and frontages are based upon conversations with Col W. E. Waters, GSC (FA), and Colonels Tipton and Ondrick, C&GSC. Ft. Leavenworth, Kansas.

The T/O for Soviet infantry is taken from Department of the Army Pamphlet 30–2 (1949), and the depths and frontages are taken from unpublished studies of captured German documents.

The various components which have been put in the areas in Figures 32 and 33 may not produce a realistic situation. It will be noticed in Table XXXVIII, for example, that the total number of men involved in the US situation is 17,113 per divisional sector, as compared with about 25,000 per Soviet divisional sector. This disparity may be correct in the *areas of offensive deployment* considered. However, it is felt that the disparity is probably not literally correct, being the result of inaccuracies in information as well as misjudgment in assumed deployment.

Tables XXXVI and XXXVII show the numerical detail of the studies on the two deployments. In each case casualties were counted unit by unit in each deployment area. In each table the left hand column identifies units shown in the figures by a serial number which has no other significance. Units shown in parentheses are actual, indicated units in the figures, used to describe identical units in that portion of the figures not containing the designations.

In each case the point of burst was chosen to inflict severe personnel casualties, without considering other factors which might have influenced a different choice. Effects on equipment and materiel are not considered. The method of choosing the point of burst did not involve a rigorous analysis, and it may be that a different choice would have led to the computation of slightly more casualties. In each case, after the height of burst had been chosen, it was verified that friendly troops would not have been within the maximum radius of damage for personnel in fox holes.

It is assumed that the bomb burst immediately after the lifting of the final artillery barrage just prior to the attack. The columns headed "N(Present)" and "N(Exposed)" in Tables XXXVI and XXXVII give the number of troops assumed to be present in each unit and the number exposed in the open at the time of the burst.

In this study, X is interpreted as the probability that a man in the open at the corresponding distance from ground zero will suffer injuries causing his death within half an hour. In the same way, Z is interpreted here as the probability that a man caught in the open within the corresponding distance from ground zero will require hospitalization if he does not die within half an hour. Average

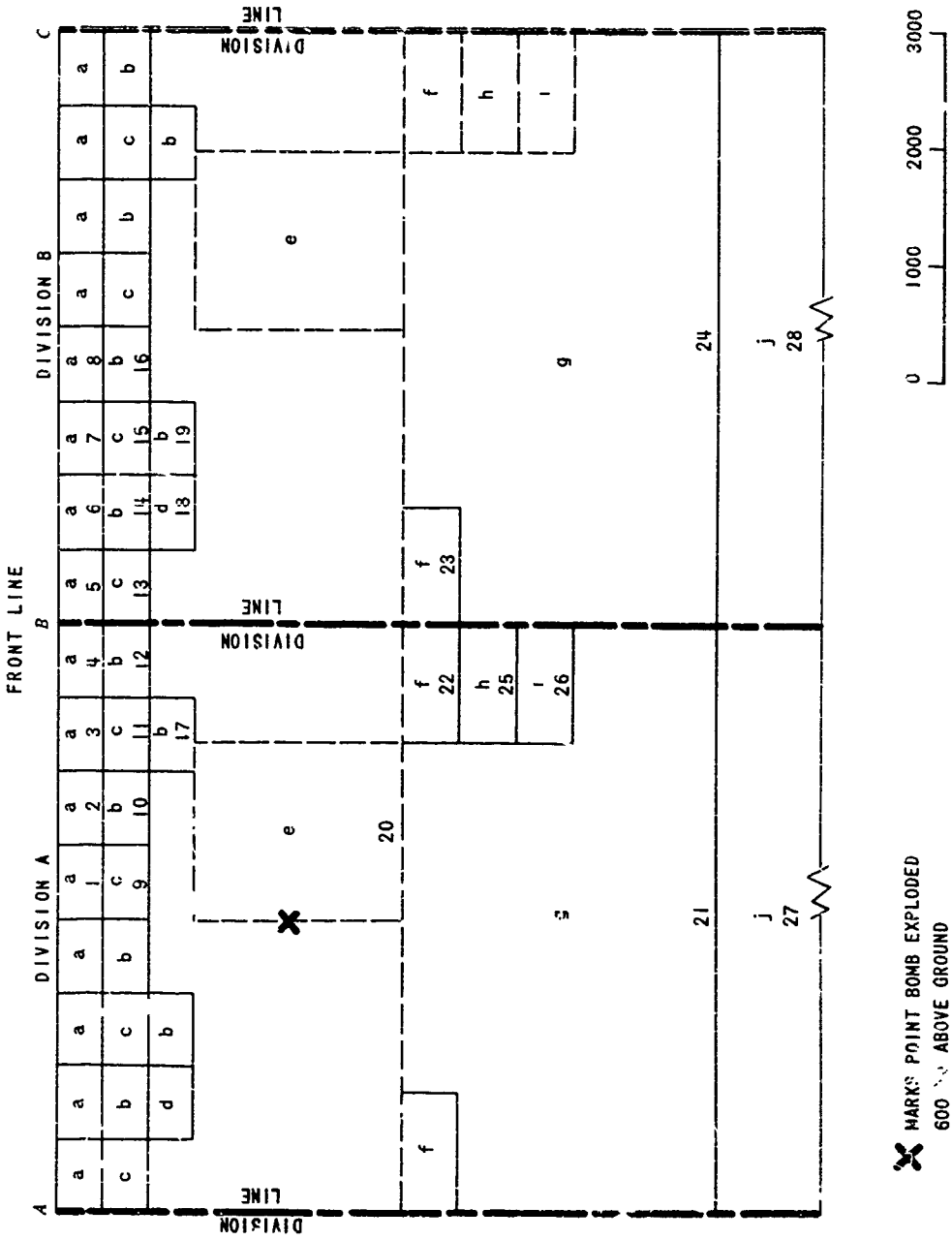

Figure 32.—US Forces Deployed for Assault, According to Standard Operating Procedure. X Marks Ground Zero of Bomb Explosion

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KEY TO FIGURE 32

Division A

a: Divisional Reinforced Co: 320
a1: Divisional Reinforced Co: 320, #1
a2: Divisional Reinforced Co: 320, #2
a3: Divisional Reinforced Co: 320, #3
a4: Divisional Reinforced Co: 320, #4
b: Divisional Reinforced Co: 370
b10: Divisional Reinforced Co: 370, #10
b12: Divisional Reinforced Co: 370, #12
b17: Divisional Reinforced Co: 370, #17
c: Divisional Engineers Co: 243
c9: Divisional Engineers Co: 243, #9
c11: Divisional Engineers Co: 243, #11
d: Divisional Reconnaissance Co: 170
e20: Divisional Tank Battalion: 700, #20
f: Regimental HQ: 50
f22: Regimental HQ: 50, #22
g21: Divisional & Corps Artillery: 5,800, #21
h25: Divisional MP Co: 187, #25
i26: Divisional Quartermaster & Ordnance Repair: 630, #26
j27: Divisional Reserve Regiment: 3,774, #27

Division B

a: Divisional Reinforced Co
a5: Divisional Reinforced Co: 320, #5
a6: Divisional Reinforced Co: 320, #6
a7: Divisional Reinforced Co: 320, #7
a8: Divisional Reinforced Co: 320, #8
b: Divisional Reinforced Co
b14: Divisional Reinforced Co: 370, #14
b16: Divisional Reinforced Co: 370, #16
b19: Divisional Reinforced Co: 370, #19
c: Divisional Engineers Co
c13: Divisional Engineers Co: 243, #13
c15: Divisional Engineers Co: 243, #15
d18: Divisional Reconnaissance Co: 170, #18
e: Divisional Tank Battalion
f: Regimental HQ: 50
f23: Regimental HQ: 50, #23
g24: Divisional and Corps Artillery: 5, 800, #24
h: Divisional MP Co: 187
i: Divisional Quartermaster & Ordnance Repair: 630
j28: Divisional Reserve Regiment: 3,774, #28

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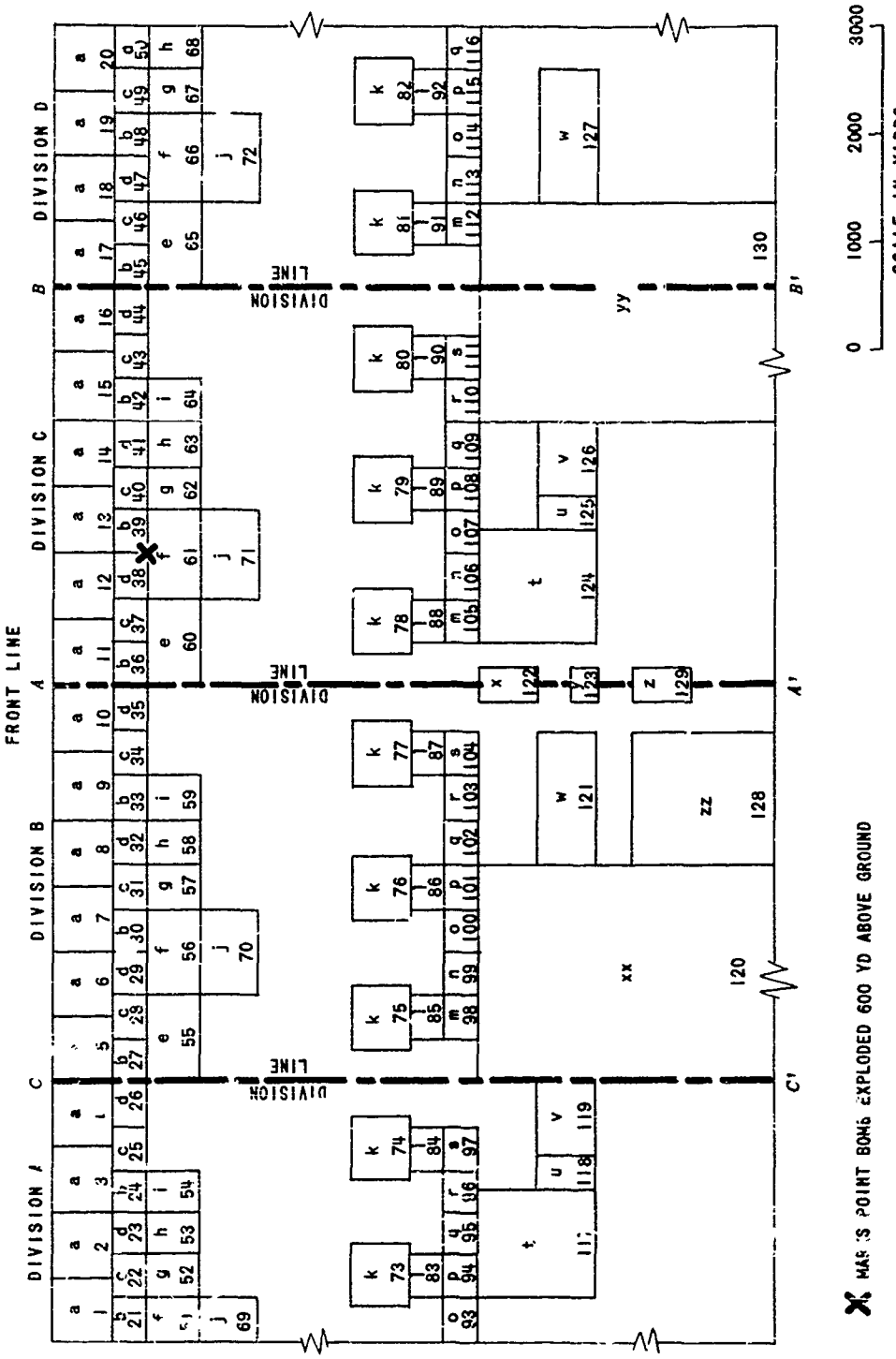

Figure 33.—USSR Forces Deployed for Assault, According to Standard Operating Procedure. X Marks Ground Zero of Bomb Explosion

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KEY TO FIGURE 33

Division A

a1 Regimental Battalion: 555, #1
a2 Regimental Battalion: 555, #2
a3 Regimental Battalion: 555, #3
a4 Regimental Battalion: 555, #4
b21 Regimental AA: 60, #21
b24 Regimental AA: 60, #24
c22 Regimental Engineers and Others: 275, #22
c25 Regimental Engineers and Others: 275, #25
d23 Regimental Artillery: 165, #23
d26. Regimental Artillery: 165, #26
f51: Divisional Artillery Brigade: 900, #51
g52 Divisional Armor: 700, #52
h53 Divisional Reconnaissance Battalion: 500, #53
i54 Corps Engineers Battalion: 500, #54
j69: One-half Corps AA Regiment: 900, #69
k73 Regimental Battalion: 555, #73
k74. Regimental Battalion: 555, #74
l83 Regimental HQ: 100, #83
l84 Regimental HQ: 100, #84
o93 Divisional Transport: 200, #93
p94: Divisional HQ: 250, #94
q95 Divisional QM: 100, #95
r96 Divisional Ordnance Repair: 100, #96
s97 Divisional Signal Battalion: 500, #97
t117. Corps Service Regiment: 2,000, #117
u118 Corps Engineers Battalion Reserve: 500, #118
v119 Corps AA Regiment Reserve: 900, #119

Division B

a5 Regimental Battalion: 555, #5
a6. Regimental Battalion: 555, #6
a7 Regimental Battalion: 555, #7
a8: Regimental Battalion: 555, #8
a9 Regimental Battalion: 555, #9
a10 Regimental Battalion: 555, #10
b27 Regimental AA: 60, #27
b30. Regimental AA: 60, #30
b33 Regimental AA: 60, #33
c28. Regimental Engineers and Others: 275, #28
c31. Regimental Engineers and Others: 275, #31
c34. Regimental Engineers and Others: 275, #34
d29 Regimental Artillery: 165, #29
d32. Regimental Artillery: 165, #32
d35 Regimental Artillery: 165, #35
e55 Corps Artillery Brigade: 1,800, #55
f56 Divisional Artillery Brigade: 1,800, #56
g57 Divisional Armor: 700, #57
h58 Divisional Reconnaissance Battalion: 500, #58
i59. Corps Engineers Battalion: 500, #59
j70 Corps AA Regiment: 900, #70
k75 Regimental Battalion: 555, #75
k76 Regimental Battalion: 555, #76
k77 Regimental Battalion: 555, #77
l85 Regimental HQ: 100, #85
l86 Regimental HQ: 100, #86
l87 Regimental HQ: 100, #87
m98 Divisional Medical Battalion: 500, #98
n99. Divisional Chemical Company: 100, #99
o100 Divisional Transport: 200, #100
p101 Divisional HQ: 250, #101
q102 Divisional QM: 100, #102
r103 Divisional Ordnance Repair: 100, #103
s104 Divisional Signal Battalion: 500, #104
w121 Corps Artillery Reserve: 1,200, #121
xx120 Mechanized Rifle Division in Reserve: 11,000, #120
zz128 Army Service Regiment: 2,000, #128

A to A' Center Line

x122 Corps Signal Battalion: 500, #122
y123 Corps HQ: 200, #123
z129 Army Signal Battalion: 500, #129

Division C

a11: Regimental Battalion: 555, #11
a12 Regimental Battalion: 555, #12
a13 Regimental Battalion: 555, #13
a14. Regimental Battalion: 555, #14
a15. Regimental Battalion: 555, #15
a16. Regimental Battalion: 555, #16
b36 Regimental AA: 60, #36
b39: Regimental AA: 60, #39
b42: Regimental AA: 60, #42
c37. Regimental Engineers and Others: 275, #37
c40 Regimental Engineers and Others: 275, #40
c43. Regimental Engineers and Others: 275, #43
d38 Regimental Artillery: 165, #38
d41. Regimental Artillery: 165, #41
d44 Regimental Artillery: 165, #44
e60 Corps Artillery Brigade: 1,800, #60
f61. Divisional Artillery Brigade: 1,800, #61
g62 Divisional Armor: 700, #62
h63 Divisional Reconnaissance Battalion: 500, #63
i64. Corps Engineers Battalion: 500, #64
j71 Corps AA Regiment: 900, #71
k78. Regimental Battalion: 555, #78
k79: Regimental Battalion: 555, #79
k80 Regimental Battalion: 555, #80
l88 Regimental HQ: 100, #88
l89: Regimental HQ: 100, #89
l90. Regimental HQ: 100, #90
m105 Divisional Medical Battalion: 500, #105
n106. Divisional Chemical Company: 100, #106
o107 Divisional Transport: 200, #107
p108. Divisional HQ: 250, #108
q109: Divisional QM: 100, #109
r110: Divisional Ordnance Repair: 100, #110
s111 Divisional Signal Battalion: 500, #111
t124: Corps Service Regiment: 2,000, #124
u125 Corps Engineers Battalion Reserve: 500, #125
v126 Corps AA Regiment Reserve: 900, #126

B to B' Line

yy130 Mechanized Rifle Division in Reserve: 11,000, #130

Division D

a17 Regimental Battalion: 555, #17
a18: Regimental Battalion: 555, #18
a19 Regimental Battalion: 555, #19
a20 Regimental Battalion: 555, #20
b45: Regimental AA: 60, #45
b48 Regimental AA: 60, #48
c46. Regimental Engineers and Others: 275, #46
c49 Regimental Engineers and Others: 275, #49
d47 Regimental Artillery: 165, #47
d50. Regimental Artillery: 165, #50
e65. Corps Artillery Brigade: 1,800, #65
f66 Divisional Artillery Brigade: 1,800, #66
g67 Divisional Armor: 700, #67
h68. Divisional Reconnaissance Battalion: 500, #68
j72 Corps AA Regiment: 900, #72
k81 Regimental Battalion: 555, #81
k82 Regimental Battalion: 555, #82
l91. Regimental HQ: 100, #91
l92 Regimental HQ: 100, #92
m112 Divisional Medical Battalion: 500, #112
n113 Divisional Chemical Company: 100, #113
o114 Divisional Transport: 200, #114
p115 Divisional HQ: 250, #115
q116 Divisional QM: 100, #116
w127 Corps Artillery Reserve: 1,200, #127

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values of X and Z appropriate to the unit designated by the serial number in the left hand columns of Tables XXXVI and XXXVII form the third and fourth columns of these tables, respectively.

The number of men killed in any given unit is simply NX, and the number hospitalized is NZ(1–X). Both of these quantities are tabulated and summed in Tables XXXVI and XXXVII. The result of one air burst over this deployment is 10,321 killed and 4,285 hospitalized for the US forces, and 16,572 killed and 6,157 hospitalized for the USSR forces. It should be noted that casualties are among several divisions, plus attachments.

To show how, in this hypothetical example, casualties would be divided between adjacent divisional areas of responsibility, these areas have been definitely laid out. In Figure 32 the rectangular area whose corners are denoted by A, A', B, and B', will be referred to as divisional area A; the corresponding rectangular area whose corners are denoted B, B', C, and C', will be referred to as divisional area B. In Figure 33 the incomplete rectangle lying to the left of the line C–C' will be denoted divisional area A, the rectangle whose corners are denoted by C, C', A, and A', will be denoted divisional area B, the rectangle whose corners are denoted by A, A', B, and B', will be denoted divisional area C, and the incomplete rectangle lying to the right of line B–B' will be referred to as divisional area D. In laying out these subdivisions of Figures 32 and 33 it is not intended to imply either that all personnel of the division are within the area at the time of the burst or that only division personnel are there. A line drawn on a map between 2 divisions may have no more than administrative significance. In the tables estimates of strengths and casualties have been included for those portions of the divisional areas not shown in the figures. Thus the numbers quoted throughout are for complete divisional areas. The sections not shown have been identified in the US tabulation (Table XXXVI) by letters and in the USSR tabulation (Table XXXVII) by parentheses.

Making use of the subdivisions defined previously, Table XXXVIII has been constructed. The percentages killed, hospitalized, and effective in armor, artillery, and other personnel in each divisional area are assembled in Table XXXIX. All casualties are assumed to be maximum. Effects on equipment and materiel will be the subject of further studies.

Of the men not killed or wounded, almost all within 5,000 yards of ground zero and many within 10,000 yards would be left somewhat dazed by the blast, and many would be temporarily blind for periods ranging from minutes to hours

Under the particular set of assumptions made here, there would be no delayed deaths—that is, no one caught in the open and not in need of immediate hospitalization would later die of gamma ray effects. Thus under the conditions assumed, it would be definitely advantageous for troops to wear dog tags which would indicate the degree to which they had been exposed to gamma rays. All those not hospitalized would be thus relieved of fear that they had been fatally irradiated.

If the particular conditions assumed here obtained over an entire army front, and if the defenders could explode atomic bombs at accurately preselected locations, a density of 1 bomb per 8,000 yards of frontage would completely break up any attack. This is 0.6 bombs per division of US troops, or 0.4 bombs per division of USSR troops.

In considering the results of this study, the highly specialized character of the assumptions used should be constantly kept in mind. The timing assumed is probably much more nearly optimum than can be anticipated from presently contemplated means of delivery. In short, the situation assumed is ideal from the point of view of the user of the bomb, and the results probably represent maximum casualties which can be inflicted on infantry in the field by a single 20 KT bomb.

It should be further kept in mind that uniforms specially designed to reduce the number of burns from the bomb flash are possible and very likely to be effective. The use of such uniforms has not been assumed here. Had this assumption been made, the computed casualties would have been much lower. Also, it has been calculated that fox holes offer very good protection from atomic bomb effects at distances greater than 800 yards from ground

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TABLE XXXVI
CASUALTIES AMONG US TROOPS

SECTION	DIV AREA	(N) PRESENT	(N) EXPOSED	X % DEATH	Z % HOSP.	NX NO. DEATHS	NZ (1-X) NO. HOSP	NX DEATHS	NZ (1-X) NO. HOSP.
1	A	320	320	95	100	304	16	304	16
2	A	320	320	89	100	285	35	285	35
3	A	320	320	70	100	224	96	224	96
4	A	320	320	28	78	90	179	90	179
5	B	320	320	10	30	32	93	32	93
6	B	320	320	03	13	10	40	10	40
7	B	320	320	01	03	3	10	3	10
8	B	320	160	00	00	0	0	0	0
9	A	243	243	99	100	241	2	241	2
10	A	370	370	98	100	362	8	362	8
11	A	243	243	85	100	206	37	206	37
12	A	370	370	50	98	185	168	185	168
13	B	243	243	14	37	34	77	34	77
14	B	370	370	05	18	19	63	19	63
15	B	243	243	02	06	5	14	5	14
16	B	370	260	01	01	3	2	3	2
17	A	370	370	95	100	352	185	352	185
18	B	170	170	06	21	10	34	10	34
19	B	370	370	02	06	7	22	7	22
20	A	700	0	00	00	0	0	0	0
21	A	5,800	5,800	82	100	1,760	1,040	4,760	1,040
22	A	50	25	79	100	20	5	20	5
23	B	50	25	14	37	4	8	4	8
24	B	5,800	2,650	03	13	80	334	80	334
25	A	187	90	50	100	45	45	45	45
26	A	630	400	21	52	84	164	84	164
27	A	3,774	1,000	03	11	30	107	30	107
28	B	3,774	1,000	00	00	0	0	0	0
(8)	A	320	320	95	100	304	16	304	16
(7)	A	320	320	89	100	28	35	285	35
(6)	A	320	320	70	100	224	96	224	96
(5)	A	320	320	28	78	90	179	90	179
(16)	A	370	370	99	100	366	4	366	4
(15)	A	243	243	98	100	238	5	238	5
(14)	A	370	370	85	100	314	56	314	56
(13)	A	243	243	50	98	122	97	122	97
(19)	A	370	370	99	100	366	4	366	4
(18)	A	170	170	95	100	352	185	352	185
(22)	A	50	25	79	100	20	5	20	5
(1)	B	320	0	00	00	0	0	0	0
(2)	B	320	0	00	00	0	0	0	0
(3)	B	320	0	00	00	0	0	0	0
(4)	B	320	0	00	00	0	0	0	0
(9)	B	243	0	00	00	0	0	0	0
(10)	B	370	0	00	00	0	0	0	0
(11)	B	243	0	00	00	0	0	0	0
(12)	B	370	0	00	00	0	0	0	0
(17)	B	370	0	00	00	0	0	0	0
(20)	B	700	0	00	00	0	0	0	0
(22)	B	50	25	00	00	0	0	0	0
(25)	B	187	90	00	00	0	0	0	0
(26)	B	630	400	00	00	0	0	0	0
(6)	C	320	320	10	30	32	93	32	93
(3)	C	320	320	03	13	10	40	10	40
(2)	C	320	320	01	03	3	10	3	10
(1)	C	320	160	00	00	0	0	0	0
(8)	C	320	0	00	00	0	0	0	0

RESTRICTED DATA
Atomic Energy Act - 1946
Specific Restrictions Contained Herein Not Required
Use Military Classification Safeguards

TABLE XXXVI (*Continued*)

SECTION	DIV AREA	(N) PRESENT	(N) EXPOSED	X % DEATH	Z % HOSP	NX NO. DEATHS	NZ (1-X) NO. HOSP.	NX NO DEATHS	NZ (1-X) NO. HOSP.
(7)	C	320	0	00	00	0		0	0
(6)	C	320	0	00	00	0		0	0
(5)	C	320	0	00	00	0		0	0
(12)	C	370	370	14	37	52	1	52	118
(11)	C	243	243	05	18	12		12	42
(10)	C	370	370	02	06	7		7	22
(9)	C	243	170	01	01	2		2	2
(16)	C	370	0	00	00	0		0	0
(15)	C	243	0	00	00	0		0	0
(14)	C	370	0	00	00	0		0	0
(13)	C	243	0	00	00	0		0	0
(17)	C	370	370	06	21	22		22	73
(19)	C	370	0	00	00	0		0	0
(18)	C	170	0	00	00	0		0	0
(20)	C	700	0	00	00	0		0	0
(22)	C	50	25	14	37	4		4	6
(25)	C	187	90	06	21	5		5	18
(26)	C	630	400	04	15	16		16	50
(21)	C	5,800	2,650	03	13	80	3	80	334
(23)	C	50	25	00	00	0		0	0
(27)	C	3,774	1,000	00	00	0		0	0
Total		51,339	27,061			10,321	4,2	10,321	4,285

TABLE XXXVII
CASUALTIES AMONG USSR TROOPS

SECTION	DIV AREA	(N) PRESENT	(N) EXPOSED	X % DEATH	Z % HOSP.	NX NO. DEATHS	NZ (1-X) NO. HOSP	NX NO. DEATHS	NZ (1-X) NO. HOSP.
1	A	555	0	00	00	0		0	0
1A	A	555	0	00	00	0		0	0
1B	A	555	0	00	00	0		0	0
2	A	555	0	00	00	0		0	0
3	A	555	0	00	00	0		0	0
4	A	555	555	00	01	0		0	0
5	B	555	555	02	07	11		11	38
6	B	555	555	05	18	28		28	95
7	B	555	555	18	43	100	1	100	196
8	B	555	555	55	100	326	2	326	229
9	B	555	555	93	100	515		515	40
10	B	555	555	100	100	555		555	0
11	C	555	555	100	100	555		555	0
12	C	555	555	100	100	555		555	0
13	C	555	555	100	100	555		555	0
14	C	555	555	100	100	555		555	0
15	C	555	555	100	100	555		555	0
16	C	555	555	93	100	515		515	40
17	D	555	555	60	100	333		333	222
18	D	555	555	18	43	100		100	196
19	D	555	555	06	20	33		33	104
20	D	555	555	03	08	17		17	92
20A	D	555	555	01	02	6		6	11
20B	D	555	0	00	00	0		0	0
21	A	60	0	00	00	0		0	0
21A	A	165	0	00	00	0		0	0
21B	A	165	0	00	00	0		0	0
21C	A	60	0	00	00	0		0	0
22	A	275	0	00	00	0		0	0
23	A	165	0	00	00	0		0	0
24	A	60	0	00	00	0		0	0

[redacted]

TABLE XXXVII (*Continued*)

SECTION	DIV AREA	(N) PRESENT	(N) EXPOSED	x % DEATH	z % HOSP.	NX NO. DEATHS	NZ (1-x) NO. HOSP.
25	A	275	140	00	00	0	0
26.	A	165	165	01	03	2	5
27.	B	60	60	02	06	1	4
28.	B	275	275	03	08	8	21
29	B	165	165	07	24	12	37
30.	B	60	60	15	39	9	20
31.	B	275	275	35	89	96	159
32.	B	165	165	70	100	115	50
33.	B	60	60	91	100	54	6
34.	B	275	275	89	100	244	31
35.	B	165	165	100	100	165	0
36.	C	60	60	100	100	60	0
37.	C	275	275	100	100	275	0
38.	C	165	165	100	100	165	0
39.	C	60	60	100	100	60	0
40	C	275	275	100	100	275	0
41.	C	165	165	100	100	165	0
42.	C	60	60	100	100	60	0
43.	C	275	275	99	100	272	3
44.	C	165	165	93	100	153	12
45.	D	60	60	70	100	42	18
46.	D	275	275	35	89	96	159
47.	D	165	165	18	43	30	58
48.	D	60	30	07	24	4	13
49.	D	275	275	04	14	11	37
50.	D	165	165	02	07	3	11
50A.	D	60	60	01	03	1	2
50B	D	275	275	00	00	0	0
50C.	D	165	0	00	00	0	0
51.	A	1,800	0	00	00	0	0
51A.	A	1,800	0	00	00	0	0
52.	A	700	0	00	00	0	0
53.	A	500	0	00	00	0	0
54	A	500	0	00	00	0	0
55.	B	1,800	1,800	03	09	54	157
56.	B	1,800	1,800	10	29	180	470
57.	B	700	0	00	00	0	0
58.	B	500	500	69	100	345	155
59.	B	500	500	91	100	455	45
60.	C	1,800	1,800	100	100	1,800	0
61.	C	1,800	1,800	100	100	1,800	0
62.	C	700	0	00	00	0	0
63.	C	500	500	100	100	500	0
64.	C	500	500	100	100	500	0
65.	D	1,800	1,800	50	98	900	882
66.	D	1,800	1,800	12	32	216	507
67	D	700	0	00	00	0	0
68.	D	500	500	02	06	10	29
68A.	D	500	500	01	03	5	15
104	B	500	250	09	28	2	70
105.	C	500	250	21	52	50	100
106.	C	100	50	23	58	12	27
107.	C	200	100	23	58	24	44
108.	C	250	125	21	52	32	46
109.	C	100	50	18	44	9	18
110.	C	100	50	14	37	7	16
111.	C	500	250	10	29	3	72
112.	D	500	250	03	11	8	25

[redacted]

TABLE [redacted]VII (*Continued*)

SECTION	DIV AREA	(N) PRESENT	(N) EXPOSED	X % DEATH	Z % HOSP.	NX NO. DEATHS	NZ (1-X) NO. HOSP.
113.	D	100	50	02	06	1	3
114..	D	200	100	01	03	1	3
115.. . . .	D	250	125	01	01	1	1
116....	D	100	0	00	00	0	0
116A	D	100	0	00	00	0	0
116B	D	500	0	00	00	0	0
117.	A	2,000	0	00	00	0	0
117A	A	3,700	0	00	00	0	0
118	A	500	0	00	00	0	0
119..	A	900	0	00	00	0	0
120.	B	11,000	3,000	01	02	30	60
121..	B	1,200	800	01	03	8	24
122..	B, C	500	250	06	20	15	59
		(B 250)	(1:1)				
		(C 250)					
123..	B, C	200	100	02	07	2	7
		(B 100)	(1:1)				
		(C 100)					
124	C	2,000	1,000	05	17	50	161
125..	C	500	250	03	08	8	20
126..	C	900	600	03	11	18	60
127..	D	1,200	300	01	01	3	3
128	B	2,000	100	00	00	0	0
129..	B, C	500	250	00	00	0	0
		(B 250)	(1:1)				
		(C 250)					
130..	C, D	11,000	5,000	02	06	100	30
		(C 7,300)	(4:1)				
		(D 3,700)					
Total	. . . . .	97,089	48,055	..	..	16,572	6,157

TABLE XXXVIII

DEATHS AND INCAPACITATIONS AMONG US AND USSR TROOPS DEPLOYED FOR ASSAULT ACCORDING TO STANDARD OPERATING PROCEDURE

		US SOP			USSR SOP			
		Area A	Area B	Area C	Area A	Area B	Area C	Area D
Armor	Present	700	700	700	700	700	700	700
	Exposed.. . .	0	0	0	0	0	0	0
	Killed....	0	0	0	0	0	0	0
	Hospitalized... . . .	0	0	0	0	0	0	0
	Effective	700	700	700	700	700	700	700
Artillery . . .	Present . .	5,800	5,800	5,800	6,075	6,375	6,075	6,375
	Exposed....	5,800	2,650	2,650	165	5,975	5,775	5,310
	Killed..... . . .	4,760	80	80	2	670	5,181	1,280
	Hospitalized . .	1,040	334	334	5	978	72	1,751
	Effective	0	5,386	5,386	6,068	4,727	822	3,344
Other	Present	10,613	10,613	10,613	15,070	22,470	19,275	12,570
	Exposed..... . .	7,162	4,316	4,183	695	10,630	12,780	6,725
	Killed..... . . .	5,169	127	165	1	2,847	5,926	665
	Hospitalized . .	1,729	363	485	6	1,447	924	974
	Effective	3,775	16,123	9,963	15,063	19,176	12,420	10,931
Total	Present	17,113	17,113	17,113	21,845	29,545	26,045	19,645
	Exposed..... . .	8,951	6,966	6,833	860	16,605	18,555	12,035
	Killed...	9,869	207	245	3	3,517	11,107	1,945
	Hospitalized . .	2,769	697	819	11	2,425	996	2,725
	Effective	4,475	16,209	16,049	21,831	23,606	13,942	14,975

[redacted]

TABLE XXXIX
CASUALTY RATIOS AMONG US AND USSR TROOPS DEPLOYED FOR ASSAULT ACCORDING TO STANDARD OPERATING PROCEDURE
(See FIGURES 32 and 33)

RATIO	DEFINITION	US RATIO IN PERCENT	USSR RATIO IN PERCENT
1. T.C. / T.3 Div	Total US killed and hospitalized divided by total number US personnel in divisional areas A, B, C.	28.5	
2. T.C. / T.4 Div.	Same as 1 for USSR divisional areas A, B, C, D.		17.1
3. C. Div. / T. Div.	Total killed and hospitalized in division divided by total number troops in divisional area:		
	a) Div. A	73.9	0.*
	b) Div. B	5.3	20.1
	c) Div. C	6.2	46.5
	d) Div. D		23.8
4. T.I. Div. / T.I. Div.	Total killed and hospitalized among personnel in divisional area not in armor and artillery, divided by total personnel in area not in armor and artillery:		
	a) Div. A	64.4	0.*
	b) Div. B	4.6	19.1
	c) Div. C	6.1	35.6
	d) Div. D		13.0
5. C.A. Div. / T.A. Div.	Total killed and hospitalized among personnel in artillery within divisional area divided by total artillery personnel in area:		
	a) Div. A	100.0	0.*
	b) Div. B	7.1	25.9
	c) Div. C	7.1	86.5
	d) Div. D		47.5

* Approximately.

zero. Finally, one should remember that the hypothetical weapons effects assumed here are grossly approximate and that, within wide limits, no one really knows what the effect of atomic bombs on troops would be. This study is merely an attempt to use the best available information to estimate the casualties to be expected—nothing more.

CONCLUSIONS

The maximum number of US ground troops deployed for assault according to Standard Operating Procedure that can be killed by the explosion of a single 20 KT atomic bomb is probably about 10,000 in the situation assumed.

The maximum number of hospital cases which can arise from the explosion of a single 20 KT atomic bomb over US troops deployed in the field is probably about 5,000 in the situation assumed.

The maximum number of USSR infantrymen deployed in the field which can be killed by the explosion of a single 20 KT atomic bomb is probably about 20,000 in the situation assumed.

The maximum number of hospital cases which can arise from the explosion of a 20 KT atomic bomb over USSR troops deployed in the field is probably about 10,000 in the situation assumed.

The largest fraction of the total personnel becoming casualties from the explosion of a single 20 KT atomic bomb over US troops in the field deployed for assault is about 30 percent. For USSR troops the fraction is about 20 percent.

The largest fraction of divisional personnel becoming casualties from the explosion of a single 20 KT atomic bomb over US troops in the field deployed for assault is about 75 percent in the division over whose center the bomb is burst. In 2 adjacent divisions the fraction of personnel becoming casualties is about 5 percent. For USSR troops similarly

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deployed and for a burst over a point 500 yards away from center of division, the fractions become about 50 percent for that division and about 20 percent for each of 2 adjacent divisions.

The largest fraction of divisional personnel not in armor or artillery becoming casualties from the explosion of a 20 KT atomic bomb over US troops in the field deployed for assault is about 60 percent in the division over whose center the bomb is burst. In 2 adjacent divisions this fraction becomes about 5 percent. For USSR troops similarly deployed and for a burst over a point 600 yards away from center of a division, the fractions become about 37 percent for that division, about 20 percent in 1 adjacent division and about 15 percent in another adjacent division.

The largest fraction of divisional artillery personnel becoming casualties from the explosion of a 20 KT atomic bomb over US troops in the field deployed for assault is close to 100 percent in the division over whose center the bomb is burst. In 2 adjacent divisions the fraction becomes about 7 percent. For USSR troops similarly deployed and for a burst over a point 600 yards away from center of a division, the fractions become about 90 percent for that division, about 25 percent in one adjacent division and about 50 percent in another adjacent division.

US ARMY IN ATTACK: OFFICIAL DOCTRINE

Main attacks are characterized by narrow zones of action, strong support of artillery, armor, and other supporting weapons, effective support of combat aviation, and deep echelonment of reserves. An average frontage for the division in attack may be 5,000 yards. Secondary attacks are usually assigned wider zones of action than is the main attack, with a consequent reduction in both strength and depth of reserves. To compensate for this lack of reserves, strong fire support is essential.

The frontage assigned to any unit in an attack varies with:

- The mission, mobility, combat power of the unit;
- The terrain;
- Available fire support; and
- Expected hostile resistance.

Units are distributed in depth to provide flexibility of maneuver, continuity in the attack, and security. For infantry units, depth of formation for combat rather than a wide extension of front is necessary in the initial deployment since the progress of battle will call for maneuvers that cannot be clearly foreseen. This condition can be met only by initial distribution in depth.

US ARMY IN DEFENSE: OFFICIAL DOCTRINE

The defense is built around a series of organized and occupied tactical localities. These tactical localities are selected with consideration for their observation and natural defensive strength, so that their retention will insure the integrity of the position. The battle position comprises a zone of resistance consisting of a number of mutually supporting defense areas disposed irregularly in width and depth, each organized for all-around defense with trenches, fox holes, obstacles, and emplacement. Tactical unity is maintained in each defensive area.

A line joining the forward edge of the most advanced organized defense areas is called the main line of resistance. It is a planning line in front of which the field artillery and other supporting fires must be able to concentrate. The contour of the main line of resistance is thus irregular in trace, with elements on it sited for frontal and flanking fire.

Divisional boundaries are extended to the range of weapons supporting all divisional units, including that of artillery attached to or supporting any divisional units on general outposts.

The width of sectors assigned to infantry units varies with the natural defensive strength of the various parts of the position; the relative importance of the sectors; the degree of control required; the number, strength, and weapons of units available; and the estimate of enemy capabilities. The necessity for control and the character of fields of fire affect the intervals which may be permitted between tactical localities. Some variation in the width of sector may arise from the necessity of adjusting them to

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[redacted]

fix responsibility for defense of critical terrain. Economy of force is obtained by assigning units in inverse proportion to the natural and artificial strength of the terrain. A division may thus cover a frontage of about 10,000 yards The extension of boundaries to the rear is influenced by the existing road met and by the routes for movement within the position.

US FIELD ARTILLERY DEPLOYMENT

The echelonment in depth of the field artillery takes into consideration the range of the various weapons, the location of the targets, and the possibilities of neutralization by hostile counterbattery fire. The echelon limited by the considerations that the the artillery must be able to concent fire in close support of the main line ance, that the foremost echelon can fi in the hostile zone, and that the rear support the rear defense areas of the position. The bulk of the light field a should be able to fire throughout the battle position.

The depth of deployment of the a may be 3,000 yards on the offense; 4,00 in the defense—reckoned from the grid line.

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ANNEX 3

ATOMIC WEAPONS IN ARMY OPERATIONS

Prepared by
W. L. WHITSON and W. B. COTTRELL

1 January 1950

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ORO-R-3

PROJECT *MAID*

1 January 1950

Annex 3

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ATOMIC WEAPONS IN ARMY OPERATIONS

SUMMARY

PROBLEM

This paper explores the problem of the employment of atomic weapons in ground operations. Preliminary determinations are sought relating to:

Decisions which should be made now with respect to atomic weapons requirements, and

A qualitative doctrine for atomic weapons analysis, for guidance in continued work.

FACTS AND ASSUMPTIONS

Thirteen atomic weapons are assumed to be possible for development within the next 10 years, including bombs, artillery shells, guided missiles, and the superbomb, most of which are not yet developed. Seven possibilities for delivering atomic weapons are listed.

From apparently feasible combinations of the weapons and means of delivery, 15 atomic weapons *systems* are listed.

Individual targets to the number of 54 are listed as having some importance in army operations.

In addition to individual targets, some composite targets are considered. It is assumed the ground operation is represented by: forces—infantry, artillery, armor, tactical air and logistics—transportation, storage.

In listing the various atomic weapons, methods of delivery, and atomic weapons systems, the pertinent characteristics of each are given and a possible time schedule for development is forecast for the dates 1950, 1951, 1952, 1955, and 1955–1960.

Eleven factors of importance in determining the military worth of a target for atomic weapons are listed and discussed.

Two principles are stated: one refers to the desirability of studying only planned targets and of not studying targets of opportunity as such in this paper; the other is a principle of dispersal wherein benefit from dispersal is offset by loss in effectiveness.

The necessary mathematical techniques are discussed on the basis of which continued work may be able to quantify parts of the work which herein are handled qualitatively for the most part.

A list of 54 targets is assessed, giving a letter of merit (e, g, f, p, n, and u in decreasing order of worth) to each target for each type of burst including air, ground, underground, underground with a base surge, underwater, as well as for radiological effects.

The assessment was first made regarding only the kind of target and the damage which could be done. Following this an assessment of the importance of the target, as well as of some of the rest of the factors already referred to was made. Finally, a single letter of merit was assigned to each target representing the over-all military worth of attacking the target.

A qualitative descriptive summary is given of the composite targets listed.

Regarding both the military worth of individual targets and the composite targets, the suitability of the various kinds of bursts and of radiological warfare is examined.

The problem of accuracy of delivery is related to the various significant parameters such as target size, damage radius, and probability for a given percentage coverage.

A synthesis of the various considerations is finally achieved which allows a selection of those atomic weapons needed for ground operations.

The work represented in this paper is qualitative and, hence, subject to revision as methods which are more analytic in nature are applied. Nevertheless, several conclusions can be stated and the necessity for continued work can be defined.

Appropriate mathematical formulation can and should be developed for the special problems imposed by the use of atomic weapons.

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No adequate solution to the general problems studied here can be obtained without a very careful and detailed analysis of complete tactical situations wherein all the components of means available and opposed are represented in sufficient detail to allow all the damage of various kinds to be integrated.

CONCLUSIONS

Artillery, infantry, and tactical air are suitable targets for atomic weapons, in that order of suitability. Armor (manned tanks) may be included as a result of current studies.

Logistical targets are *not* suitable targets for planned attacks with atomic weapons. Ports may be an exception.

The air burst atomic bomb is an excellent weapon for many types of targets of importance in ground operations.

There are, however, several important targets for which an air burst is not suitable. Some require a ground or underground explosion.

Underground or underwater bursts are important. The actual effect of the former is not now known, but if predictions are correct the underground burst may be better than the air burst for many targets.

A guided missile giving much greater accuracy than that of present radar bombing would cause greater damage to many types of targets, but not to all.

A field artillery shell of 1 KT energy is not as good a weapon as a 20 KT bomb, as concluded from accuracy and damage considerations, and aside from considerations of weather and deliverability in general.

An 80 KT bomb is much preferred to a 20 KT bomb for various targets

The effect of superbombs on ground operations is problematical, though potentially the resultant destruction is so great that its use would revolutionize ground operations.

RECOMMENDATIONS

The effect of an underground explosion should be determined without delay.

An atomic warhead and an appropriate vehicle such as Hermes A-1 or Corporal E should be developed for use, if possible, within a year.

An atomic warhead for an artillery shell is probably a very good interim weapon for use in ground operations and should be developed without delay.

A superbomb should be developed without delay, but work upon such a new development should not interrupt nor interfere with the continued development of fission type atomic weapons.

Use of large quantities of atomic weapons in all large scale ground operations should be planned.

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ATOMIC WEAPONS IN ARMY OPERATIONS

INTRODUCTION

Much has already been written on the subject of tactical employment of atomic weapons. Early in 1949 a paper entitled, *Tactical Employment of the Atomic Bomb,* was written in the Army Field Forces in which, among other things, it was emphasized that in World War II several concentrations of military personnel offered good targets for atomic bombs. A short time later WSEG (Weapons Systems Evaluation Group) Staff Study 1 entitled, *A Study on Tactical Use of the Atomic Bomb,* pointed out other suitable situations in World War II in which the atomic bomb could have been used, such as concentrations of ships, landing craft, aircraft, and supplies, and emphasized the necessity for re-examination of many tactical situations for possible employment of the atomic bomb.

At approximately the same time, Sandia Base of the AFSWP (Armed Forces Special Weapons Project) submitted SB/15–TS–1615 entitled, *Employment of Atomic Weapons Against Various Types of Targets.* In this report an extensive analysis of atomic weapons effects is given, as well as a rather thorough though qualitative analysis of effectiveness against many particular targets. Also, in the same report there is presented a qualitative analysis of the effect on various kinds of tactical situations such as troops in the open and under cover, rapid breakthrough, river crossings, air formations, air bases, naval targets, amphibious forces, and airborne assembly areas. Currently in process is an analysis in the Air Intelligence Division, USAF, entitled, *Tactical Targets Suitable for Attack with Air-Burst Atomic Bombs.* This study will assess the damage which can be done to various types of tactical targets. This latter analysis is understood to include only targets which would be in rather permanent physical being in contrast to the targets presented by maneuvering soldiers and equipment.

The purpose in the present study is to take account of the information already available and then to explore the possibilities for more quantitative analysis. It is proposed to set up techniques for analysis, giving some evidence of the value of the techniques and to indicate the scope of the work which still remains to be done.

It is preferred in this study to discuss in general the use of atomic weapons in all ground operations. This subject thus differs from what is ordinarily indicated by the topic "tactical employment." There are two major questions of current importance:

1. How many atomic bombs should be used in support of ground operations in contrast with those used for "strategic" bombing?

2. What new atomic weapons should be developed?

These two questions which have separate significance can be restated in terms of a general requirement for ground operations as: On the basis of their necessity, suitability, and effectiveness, what family of atomic weapons should be developed for ground operations? In considering this question, the atomic bomb in its present form should be weighed heavily because it is the only weapon in being. However, it is judged that the most suitable analysis for guidance in weapons development is one which impartially regards what is possible and necessary to build for the future in addition to that which is now available. Accordingly, the present study will consider all possible atomic weapons, and will attempt to forecast the atomic weapons systems which are possible of development by 1950, 1951, 1952, 1955, and 1955–1960.

Of those atomic weapons which might be developed, a selection must be made on the basis of utility. This is a prodigious task. Even though the atomic bomb has been "lived with" for several years and has become commonplace to a degree as a result of con-

siderable warranted as well as some erroneous debunking, it is still by far the most potent weapon ever developed. Its effects being multiple and its being an unprecedentedly a large area weapon, the problem of target analysis is extremely difficult. The initial attitude here will be: *if necessary* an atomic weapon can be designed to destroy almost any target—certainly all those any previous weapons have been capable of destroying. Indeed, part of the problem of designing appropriate weapons for ground operations is in assuring that certain targets *will not* be destroyed, i.e., friendly troops. Defining a sufficiently inclusive target complex for atomic weapons is again difficult. A superbomb (presuming such can and will be developed) is capable in some circumstances of putting an entire army out of action. This is demonstrated by the fact that in World War II the US First Army at several phases of its operations in the European Theater was composed of 8–17 divisions along a 20-mile front and could have been almost completely destroyed by one superbomb. In contrast, a single bridge or tunnel or command post may become of sufficient importance in the course of action to warrant the use of an appropriately designed atomic weapon. A decision that an atomic weapon should be used against any particular target must consider many factors. An attempt will be made in this study to take into account all these factors. It will not be possible, of course, to give a final analysis here. It is thought, however, that a rough analysis will be profitable in defining the problem for future work and will also indicate some important preliminary conclusions. Much detailed analysis which has never been done, can and must be done before a complete evaluation is possible. This paper will inspect the possibilities for such analysis.

WEAPONS SYSTEMS ANALYSIS

The one available atomic weapons system is that used against the Japanese, an air burst atomic bomb delivered on the target by aircraft. Requisite to the tabulation of this existing weapons system and those that can be assumed to be possible of development within the next few years, is the knowledge of atomic weapons developments and possible methods of delivery. The analysis presented here, therefore, includes separately those atomic weapons and those methods of delivery for which there is assumed to be a reasonable probability of development. Following this, the possible weapons systems are proposed.

TYPES OF ATOMIC WEAPONS

An exhaustive list of possibilities for atomic weapons is not attempted here. Rather, later in this paper, the need for certain types of weapons is discussed and the list given in Table XL merely anticipates the needs of the subsequent target analysis.

METHODS OF DELIVERY

There has been considerable reluctance in reports already written to include for consideration an atomic warhead on a guided missile. This tendency apparently results from a general belief that neither the atomic warhead nor the guided missile will be available for many years. There is a growing conviction, however, that if there is sufficient necessity such a weapon could be obtained in one year. Corporal E and Hermes A–1 which are listed in Table XLI are in this category. Certainly the guided missiles which may be available in five years will have better characteristics, but the anticipated characteristics of both Corporal E and Hermes A–1 make them acceptable as carriers for an atomic weapon of the modified LC type.

ATOMIC WEAPONS SYSTEMS

If the atomic weapons which can be assumed to be possible of development in the next few years are correlated with the development of methods of delivery, the possibilities for weapons systems can be outlined. Table XLII lists 15 different weapons systems. A final selection of the best weapons systems from this list cannot be made until after a consideration of the target system in the next section. It is apparent that a decision to put atomic warheads on guided missiles would be made primarily to obtain greater accuracy than is obtainable in high altitude bombing.

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TABLE XL

ATOMIC WEAPONS ASSUMED POSSIBLE OF DEVELOPMENT WITHIN THE NEXT TEN YEARS

MISSILE TYPE	ENERGY IN KT	POSSIBLE KINDS OF BURST	EARLIEST ESTIMATED AVAIL-ABILITY	REMARKS
1. Bomb	40	Air Ground	Now	Only airburst type used and now available.
2 Bomb	20	Air	Now	Considered obsolete.
3. Bomb		Ground Underground Underwater Air	1950	Penetrating weapon. Not tested but assumed effective. Underground effects not yet determined.
4. RW (Bomb or Shell)		Air	1950	Small quantity available almost immediately. Larger quantities believed possible. No decision to make in large quantity (1 January 1950).
5. Bomb	Higher than #1	Air Ground	1951	Improved type.
6. Guided Missile		Air Ground	1951	No decision to develop (1 January 1950). To fit on Corporal E, Hermes A-1 or Hermes A-3.
7. Field Artillery Shell	Low	Air Ground	1951	No decision to develop (1 January 1950). Fired in 280 mm howitzer like T-29.
8. Bomb		Ground Underground Underwater Air	1951	Possibly using jet assists to penetration. No plans to develop (1 January 1950).
9. Superbomb		Air Ground	1955	Status not known (1 January 1950).
10. Super-Guided Missile		Air Ground Underground Underwater	1955–60	
11. Superbomb or Super-Guided Missile		Air Ground Underground Underwater	1955–60	
12. Field Artillery Shell	Higher than #7	Air Ground	1951	
13. Guided Missile		Air Ground Underground Underwater	1955	

TABLE XLI—METHODS OF DELIVERY OF ATOMIC WEAPONS

METHOD	CARRIER	MAXIMUM RANGE	ACCURACY	EARLIEST ESTIMATED AVAILABILITY	REMARKS
		miles	*feet*		
1. Airplane	B-29 B-36 B-50	More than 5,000	1,500 (cpe) visual 3,000 (cpe)	Now	Accuracy is understood to be controversial.
2. Airplane	Drone (Heavy Bomber)	. . . .	Not known	Not known	Availability is estimated here as 1950 but no plans are referred to.
3. Field Artillery	T-29	25	900 range pe estimated	1951	Conventional shell weight approximately 400 lbs. Not yet test fired. Caliber 280 mm.
4. Guided Missile	Corporal E	80 (approx.)	1,000 (cpe) estimated	1951	Remaining development work required on guidance system only. Guidance to be proved in fall 1950
5. Guided Missile	Hermes A-1	30 (approx.)	300 (cpe) estimated	1951	Current estimates 12 months development time for guidance system.
6. Guided Missile	Hermes A-3	150	200 (cpe) estimated	1955	Planned. Several other guided missiles are also under development.
7. Guided Missile	. . . . .	More than 400	Better than 500 cpe	1955–1960	Must carry atomic warhead. No known plans to develop.

TABLE XLII—POSSIBLE ATOMIC WEAPONS SYSTEMS

EARLIEST ESTIMATED AVAILABILITY	METHOD OF DELIVERY	MAXIMUM RANGE	ACCURACY	ATOMIC WEAPON	ENERGY IN KT	TYPE OF BURST
		miles	*feet*			
1. Now	Airplane	More than 5,000	1,500 or 3,000 cpe	Bomb	Up to 40	Air
2. 1950	Piloted airplane or drone; low altitude	.	Less than 1,000 cpe estimated	Bomb	Up to 40	Air
3. 1950	Airplane	More than 5,000	1,500 or 3,000 cpe	Bomb	. . . . .	Ground Underground Air
4. 1950	Airplane	More than 5,000	1,500 or 3,000 cpe	RW	. . . . .	Air
5. 1951	Guided bomb on airplane	. . .	Less than 1,000 cpe estimated	Bomb	Up to 40	Air
6. 1951	Airplane	More than 5,000	1,500 or 3,000 cpe	Improved Bomb	Higher than #1	Air
7. 1951	Field Artillery	25	900 range pe estimated	Shell	Low	Air
8. 1951 [1]	Airplane	More than 5,000	1,500 or 3,000 cpe	Bomb	. . . . .	Ground Underground Underwater
9. 1951	Guided Missile Hermes A-1	75 (approx.)	300 cpe	Bomb Warhead	. . . . .	Air
10. 1951	Guided Missile Corporal E	80 (approx.)	1,000 cpe estimated	Bomb Warhead	. . . . .	Air
11. 1955	Airplane	More than 5,000	1,500 or 3,000 cpe	Super	. . . . .	Air
12. 1955	Guided Missile Hermes A-3	150	200 cpe estimated	Bomb Warhead	. . . . .	Air
13. 1951	Field Artillery	25	900 range pe estimated	Shell	. . . . .	Air
14. 1955	Guided Missile	150	200 cpe estimated	Bomb Warhead	. . . .	Air
15. 1955–60	Guided Missile	400	200 cpe estimated	Super	. . . . .	Air

[1] Jets for additional penetration.

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TARGET SYSTEMS ANALYSIS

Analysis of target systems to determine their suitability for attack by atomic weapons is a very difficult task. It has been pointed out that the target complex, depending on the type of atomic weapon or the tactical configuration, may be considered to range from an entire army down to a single relatively small target such as a ship, a tunnel, or a depot. What is the effect of specific damage on the capacity of an army to fight? What decrease in effectiveness accompanies any specific fractional loss in infantry, artillery or supplies? Will there be a psychological reaction to the use of atomic weapons in the field which will be even more important than the physical destruction? These are all exceedingly difficult questions to approach. Nevertheless, it is believed that any analysis which does not give some kind of reply, however qualified, to such questions is not adequate. It is necessary to show the relationship between specific damage to personnel or equipment and the military capability of the entire unit. The saturation type of operation would simplify the analysis. That is to say, if *all* the infantry, or *all* the long range artillery, or *all* the tactical aircraft, or *all* the food could be destroyed, the fighting potential of the unit could be evaluated more easily. It is possible that atomic weapons may be shown to be adaptable to attacks of this kind and the appropriate analysis should be considered very profitable.

It is not implied that such a comprehensive and detailed analysis has been completed. Rather, since such analyses are a vital necessity to the most thorough appreciation of the position of atomic weapons in army operations, a beginning is made toward this end. A preliminary analysis has been made of a number of individual targets, and this has been extended to analysis of the effects on a few composite targets. Even from these beginnings, specific conclusions may be reached as to the requirement for weapons with increased accuracy of delivery (against individual targets), and the effectiveness of the weapon against some composite targets.

FACTORS IN EVALUATION

Before attempting an analysis of targets systems it is appropriate to consider the factors involved in the decision to employ an atomic weapon against a particular target. The most important of these factors are listed.

1. Size and nature of target;
2. Effect desired;
3. Delivery: means, accuracy and countermeasures;
4. Importance of the target to the military operation;
5. Danger to friendly personnel or equipment;
6. Coordination with scheme of maneuver;
7. Availability of atomic weapons;
8. Other means of neutralizing targets;
9. Other possible, current or future use of atomic weapons;
10. Expected enemy reaction;
11. Political considerations.

Together these factors may be said to determine the "Military Worth" of the target. Consideration of these factors will indicate the complexity of a consideration to use atomic weapons in the field. The size and nature of the target (1) and the effect desired (2) are the prime factors in any analysis of the effectiveness of a particular weapon against a particular target. As a first attempt at evaluating the usefulness of atomic weapons, an analysis based upon only these two factors has been made. Such an analysis involves an understanding of the phenomenology of various types of atomic bursts and an estimation of the effect of these phenomena on the particular targets. The more complete analysis also presented in this report evaluates, where possible, not only the weapons effectiveness but all other factors.

The importance of the target (4) is determined not only by the intrinsic nature of the target but in most cases by the particular situation. If it can be stated axiomatically that a certain target of a given size or dollar value is always significant to the success of ground operations, then that target is important because of its intrinsic value. There will, however, be many cases in which targets of little intrinsic value will assume overriding importance in a particular situation as, for instance, the now classic example of Remagen Bridge. Certainly no categorical statement can be made as to the relative importance of

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Use Military Classification Safeguards

targets unless the effect on the operation is shown.

The atomic weapon has such a large damage area that any ground operations will have to be extremely well coordinated, not only to minimize the danger to friendly personnel and equipment (5) but also to fully exploit the havoc wrought upon the enemy (6). The degree of the coordination required is closely associated with the means and accuracy of delivery (3) since the accuracy determines how close to friendly positions the weapon may be used as well as the probability of destroying part or all of the target.

Of particular significance in the employment of atomic weapons is the problem of procurement (7) considered in conjunction with alternative uses of the weapon (9) and alternative means of neutralizing the targets (8). In this connection it should be fully appreciated that atomic weapons are expensive and not available in unlimited quantity, thus the decision to use them must consider the factor of supply at the particular time and place as well as the economics of neutralizing the particular target by other means. On the other hand, initial consideration of the employment of atomic weapons should not be limited by the actual current availability of weapons or future production plans. Rather, a benefit of analysis, unrestricted in this report, may be to influence planning for production.

The reaction of the enemy to the use of an atomic weapon (10) must be appraised to the extent that his alternative courses of action may be anticipated. Also unavoidably involved are subsequent political considerations (11) both at home and abroad.

CLASSES OF TARGETS

Should it be so desired, an atomic weapon probably could be designed that would destroy any particular target. This, however, is not advisable, and it is the purpose of this report to propose a family of atomic weapons most suitable for ground operations.

Two important principles will now be stated:

1. *Tactical planning in advance of the battle cannot evaluate the importance of targets of opportunity.* Although it is difficult categorically to define a target of opportunity, it is sufficient for the present use to mention some targets. A fleeting target set up momentarily in the course of events is certainly such a target. However, infantry maneuvering in the field need not be classified as a target of opportunity if it is not necessary to know their location very accurately. If it is a sufficiently permanent target and if intelligence of its existence is available for planning purposes, then it would not be so classified. If, however, the existence and description of a depot or dump becomes known during the battle, it probably should be considered a target of opportunity. The suggestion in stating the above principle is *not that targets of opportunity are unimportant;* they may even be decisive. Planning, however, *cannot* reliably anticipate their importance *and this paper will not be concerned with such targets.* Further work will consider targets of opportunity so that a family of atomic weapons can be proposed having versatility necessary to allow their use on such targets.

2. *Defense against atomic weapons requires dispersal of or more protection of personnel and facilities.* This doctrine for defense against atomic weapons has been established for some years. Two questions must always be answered: What dispersal is necessary to reduce the calculated risk acceptably? How much and what kind of dispersal is possible without reducing the efficiency of the organization? The doctrine of dispersal is dangerous in application unless it can be quantified with respect to calculated risk and loss in efficiency. In the present work very little attention can be given to the effect of the use of atomic weapons on tactics. Continued work must take this into account so that weapons will be planned as much as possible for the operations *anticipated for wars of the future.*

For the present purpose "planned" targets are considered as being in one of two categories, either individual targets as entities, or in conjunction with other individual targets constituting a composite target.

Individual Targets.— For the purpose of this report an individual target may be defined as the smallest entity of defined characteristics and limited dimensions which needs to be considered from the point of view of analysis. A

[redacted]

list of individual targets, i.e., air fields, marshalling yards, ports, bridges, depots, dumps, staging areas, and tanks, which are common in military operations, has been assembled and analyzed in the light of the consideration involved in the employment of atomic weapons which have previously been discussed.

It becomes apparent from the definition of an individual target and the probable capabilities of conceivable atomic weapons and weapons systems that most such targets could probably be destroyed. However, of greater consequence than the destruction of a single individual target is the analysis of the effect of the loss of such targets on all army operations.

Composite Targets.—In general, composite targets consist of a number of individual targets which may be grouped into categories according to some common characteristics. Thus, one may think of composite targets in terms of the organizational structure of the army, the functional structure of operations, or possibly in terms of specific type targets, i.e., personnel and buildings. Atomic weapons produce damage areas so large that while assessment of damage to individual targets is requisite as a first step in analysis, the more difficult task is to associate the damage to individual targets into an integrated figure of merit which may be used to interpret the overall importance of the damage.

Significant also is the effect of atomic weapons upon the functional structure of the army. This structure may be approximated (in its aspects of significance for this purpose) by the following:

1. Forces—
   a. Infantry,
   b. Armor,
   c. Artillery,
   d. Tactical Air.
2. Logistics—
   a. Transportation,
   b. Storage.

Starting with an analysis of the individual targets which comprise the preceding elements of a ground army, it is possible to estimate the general suitability of each for attack by atomic weapons.

MATHEMATICAL TECHNIQUES OF ANALYSIS

Reasonably rigorous mathematical solutions are required in certain phases of the problem. Reference to the list of eleven factors shows that it is only remotely possible to quantify some of the factors and thus, in general, it will be very difficult to associate all the factors in a quantitative fashion. However, many factors are quantifiable and it is a purpose of this paper to outline some of the techniques which may be utilized or which would be developed.

Although much work has been done in the past on statistical analysis of conventional weapons systems, atomic weapons require much additional analysis. This results primarily from the cost and availability of atomic weapons as well as their large destructive area. Thus, one is extremely careful to determine the certainty of results when using even one atomic bomb, and when more than one is required (by the size or importance of the target) similar caution is taken to minimize the possibility of overlap. This is in contrast to the statistical problem of neutralizing a large target with high explosives in which the probability of damage is the prime concern, and with little regard for overlap a sufficient number of bombs is dropped on a target to bring the probability of destruction up to a required value.

In considering atomic weapons, the analysis must take into account at least four situations:

1. A single bomb is expended on a single target.
2. Several bombs are expended on a single target.
3. One bomb per target is expended on each of a number of targets.
4. Several bombs per target are expended on a number of targets.

In situation 1, the decision to use *one* atomic weapon on *one* target would no doubt be made only if a very high probability (perhaps 90 to 95 percent) existed for causing requisite damage to the target. That is to say, the commander typically will say here is a target which is of sufficient importance to call for an atomic bomb but only if there is a *very* good chance

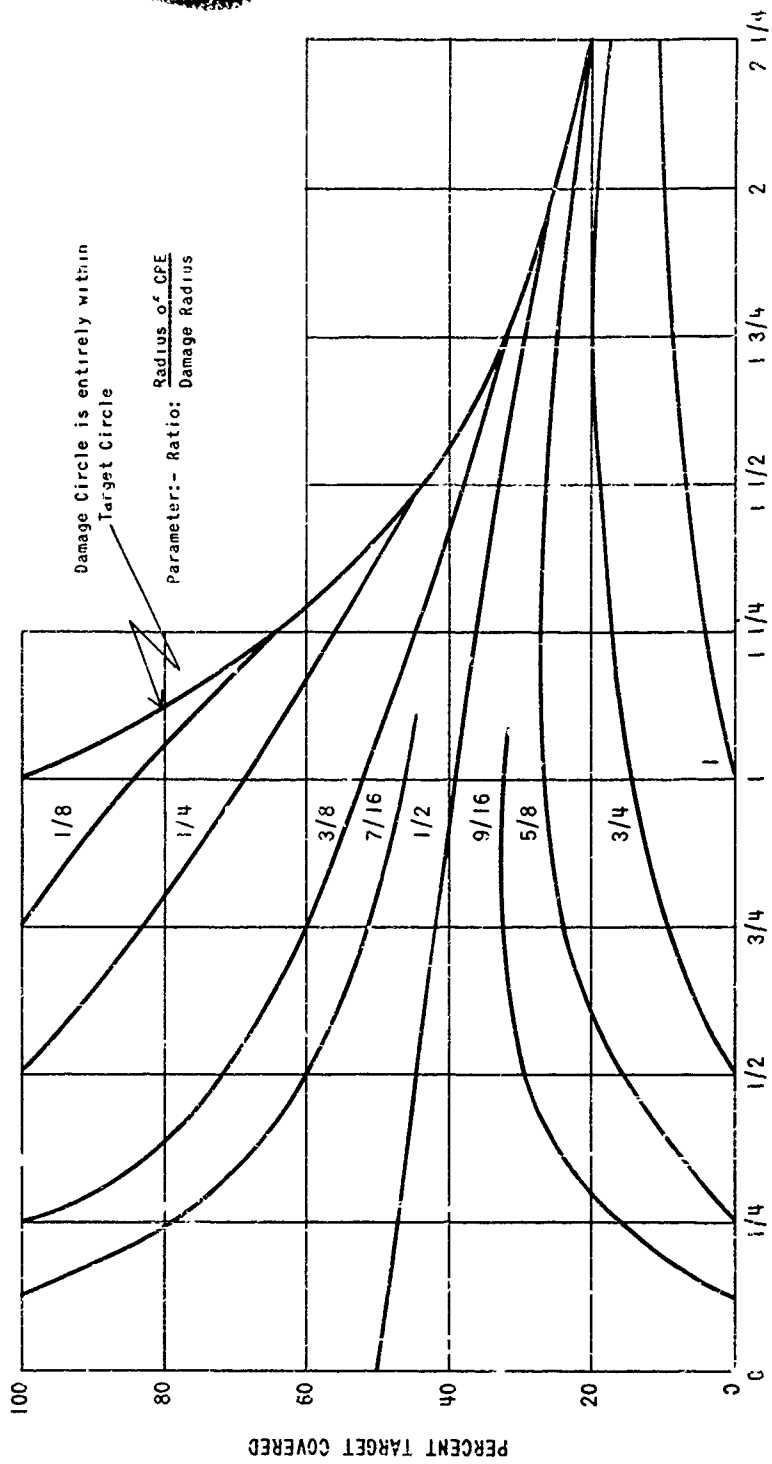

Figure 34.—Minimum Percentage of Circular Target Covered with .937 Probability for Various Ratios of Target and Bomb Radii

that this *one* bomb dropped on the target will do the job; otherwise, some other weapon should be used. It is likely that many targets will be in this category—worth *one* atomic weapon but no more.

Distinguishable from this is situation 2 in which the target is important enough to require more than one atomic weapon. Several cases can be imagined. For example, a target is of such a size that one atomic weapon falling at the proper place will knock it out but with a probability of only 5 percent. However, the probability is better than 9 percent that any one of three bombs aimed at the same point will do the required damage; and the commander says it is worth three bombs. Another example is a target so large that one bomb will under no circumstances do the requisite damage. If the target is worth several bombs, they can be used.

In situation 3, suppose there are 50 marshalling yards and 25 such yards knocked out warrants the use of 50 atomic bombs. This is again recognized to be a different situation for if one atomic bomb could be dropped on each target, even if the probability for hitting each target were only 5 percent, the over-all probability of hitting 25 or more targets would be high.

Situation 4 requires the most general statistical treatment. Much work has already been done to treat the case of several atomic bombs dropped on industrial areas. It is understood, however, that the necessary mathematics has been developed only for a single aiming point. The more general situation in which several atomic weapons are aimed in a pattern is of great importance, particularly for a consideration of the utility of guided missile weapons systems with a range up to 150 miles, which are purportedly much more accurate than high altitude bombing.

A separate mathematical formulation is not necessary for each of these four situations discussed above. Situation 1 is a special case of situation 3. Figure 34 indicates the kind of analysis which is profitable for situation 1 for .937 probability (2 circular probable error). A complete analysis of this type is in progress in this office. Situation 2 has already been analyzed for the case of a single aiming point (RAND Report R-163, *Empirical Bomb-Coverage Distribution*) but not for multiple aiming points. The latter, however, is again a special case under situation 4.

TARGET ANALYSIS

INDIVIDUAL TARGETS

As a first step in target analysis a qualitative examination has been made of various individual targets and the results are shown in Table XLIII. Such a procedure is profitable to compare the results with other similar reports, to serve as a guide to more quantitative analysis and, finally, to allow a current estimate of the need for developing certain weapons and weapons systems.

Referring to the list of factors in evaluation, an estimate has been made on the basis of 1, 2, and 3 only of the damage to the target—*assuming the weapon is properly placed*—of various types of bursts and is called *Weapons Effectiveness*. A separate estimate, made with principal concern for factor 4, and with some concern for factors 5 to 11, has been called *Target Suitability*. It is assumed here that all the weapons and methods of delivery in Tables XL, XLI, and XLII are available. The weapons system required for each target will not be stated initially

The list of targets is not exhaustive. It does, however, include all the targets analyzed in all other reports which are pertinent to the present analysis.

In Table XLIII under atomic weapons effectiveness, the type of atomic weapon considered is indicated at the top of each column. The letters used represent the following types of weapons:

Letters	*Type of Weapon*
A . .	Air Burst (more than 300 yards above surface).
G . . .	Ground Burst (immediate vicinity of ground).
UG. . .	Underground Burst (without surge).
UGS. .	Underground Burst (with surge): It will be assumed here that an underground burst will weaken the substructure and give an earth displacement [illegible] will deform the ground over a large area.
UW. .	Underwater Burst (with surge): In this analysis all references to an underwater burst in which the target is not obviously situated near sufficient water to produce this type is not applicable. Obviously a few situations may arise where this is not true, but these situations will be in the minority.
RW. .	Radiological Munitions.

The various classifications of target importance and weapons effectiveness on the target are given below with the symbol used in the analysis.

Symbol	*Classification*
e	excellent
g	good
f	fair
p	poor
n	no good
u	not applicable

In Table XLIV a single letter of merit is given which is the letter of merit for target suitability multiplied by the letter of merit for weapons effectiveness (both from Table XLIII). The product called "Military Worth" is obtained according to the following schedule:

e·e=e
e·g=g
g·g=g
e·f=f
g·f=f
e·p=f
f·f=f
g·p=p
f·p=p
p·p=p
n or u·anything=n

Table XLIV also lists for comparison the results of the Air Force Intelligence [32] and Sandia Base [33] studies. This is not a fair representation of either of these reports since it was necessary to change nomenclature in some instances. It will be noticed that there is good agreement between these analyses.

	Symbol	*Suitability*
1. Air Force	d	doubtful
	s	suitable
	u	unsuitable
2. Sandia Base	d	doubtful
	Y	yes (suitable)
	no	no (unsuitable)

The letters representing weapon types and the symbols of the various classifications of military worth used in the analysis by Operations Research Office have the same significance as previously described for Table XLIII.

The targets in Table XLIV will be discussed very briefly in explanation of the assessed military worth.

FORCES—INFANTRY

Staging Area for Airborne Assault.—An "excellent" target for an air burst atomic weapon, not only because the infantrymen would be concentrated in the open but because of the potentialities of this group if allowed to embark on the offensive. A base-surge-forming underground burst is "good" even though the thermal effects are nil and the blast area is far short of that of an air burst because the highly radioactive surge is compensatory.

Airheads.—A "good" target for an air or ground burst atomic weapon, since it is extremely vulnerable and important. Some aircraft and supplies will also be affected although the functions of the airhead may be resumed a short time after the burst. An underground burst with surge is also "good" because of the cratering and contamination effects. In any case, a time element is involved since an airhead would be of importance for several hours at the most.

Staging Area for Amphibious Assault.—An "excellent" target for either an air burst or underwater burst atomic weapon. This target is indicative of a concentration of infantry for an offensive. The underwater burst would have some limitations as the prevailing winds would have to carry the contaminated surge material over the staging area.

Amphibious Landing.—The considerations involved here are identical with those of an amphibious assault staging area.

Billets.—A "fair" target for an air and ground burst or an underground burst with a surge. A reasonable concentration of troops must be found, if not in the open, at least in structures which are vulnerable to air or ground burst weapons. The underground burst with surge would have less destructive capacity, but would make a large area unuseable.

Command Posts.—A "good" target for an underground burst atomic weapon, preferably with a base surge. While the personnel in-

[32] *Tactical Targets Suitable for Attack with Air-Burst Atomic Bombs* (Unpublished).
[33] *Employment of Atomic Weapons Against Various Types of Targets.*

[redacted]

TABLE XLIII
INDIVIDUAL TARGET EVALUATION

TARGETS	TARGET[1] SUIT-ABILITY	ATOMIC WEAPONS EFFECTIVENESS TYPE OF BURST						EFFECTIVENESS BST	
		A	G	UG	UGS	UW	RW	GS	UW
I. Forces:									
A. Infantry:									
1. Staging Area for Airborne Assault	e	e	g	f	g	u	f	g	u
2. Airheads	g	e	g	p	g	u	p	g	u
3. Staging Area for Amphibious Assault	e	e	g	p	f	e	f	f	e
4. Amphibious Landing	e	e	g	p	f	e	f	f	e
5. Billets	f	e	g	p	g	u	f	g	u
6. Command Posts[2]	e	n	p	g	g	u	n	g	u
7. Defiles (Troops)	e	g	f	f	g	u	p	g	u
8. Fixed Fortifications	e	n	n	f	f	u	n	f	u
9. Infantry (Attacking)	e	e	g	p	f	u	p	f	u
10. Infantry (Defending light fortification)	e	f	p	p	f	u	f	f	u
11. Troop Assembly Areas	e	e	f	p	f	u	f	f	u
B. Armor:									
1. Tanks	e	f	g	f	f	u	u	f	u
C. Artillery:									
1. Artillery, manned	e	e	g	p	f	u	f	f	u
2. Artillery, equipment	e	p	f	p	p	u	n	p	u
D. Tactical Air:									
1. Airfields	e	f	p	g	g	u	n	g	u
II. Logistics:									
A. Transportation:									
1. Barge Concentrations	n	p	e	u	u	e	n	u	e
2. Canal Locks	g	p	p	f	f	p	n	f	p
3. Highway Bridges and Viaducts	e	p	g	g	g	u	n	g	u
4. Highway Right of Ways	n	n	p	p	p	u	n	p	u
5. Motor Vehicle Repair Facilities	p	e	f	p	f	u	f	f	u
6. Port Areas[3]	e	f	p	p	p	f	n	p	f
7. Railheads	n	n	n	f	f	u	n	f	u
8. Railroad Bridges and Trestles	g	p	g	g	g	u	n	g	u
9. Railroad Maintenance and Repair Shops	g	e	p	p	p	u	n	p	u
10. Railroad Marshalling Yards	p	p	f	g	e	u	n	g	u
11. Railroad Right of Ways	n	n	n	f	f	u	n	f	u
12. Railroad Transfer Points	f	p	f	g	e	u	f	g	u
13. Shipyards, Naval Operating Bases	g	e	p	p	p	p	n	p	p
14. Tunnels	e	n	n	g	g	u	n	g	u
15. Vehicles and Equipment Assembly Areas	g	e	[illegible]	p	f	u	f	f	u
G. Storage:									
1. Ammunition Depot	p	p	p	f	f	u	n	f	u
2. Gas Dump (POL)	p	e	e	e	e	u	p	e	u
3. Oil Refineries	e	f	p	g	g	u	p	g	u
4. Oil Storage Tanks	g	e	f	g	g	u	n	g	u
5. Pipelines and Pumping Stations	p	n	p	p	p	u	n	p	u
6. Port Depots	e	p	n	p	p	f	n	p	f
7. Reservoirs and Aqueducts	p	n	p	g	g	n	n	g	n
8. Solid Fuel Storage	p	p	p	p	p	u	n	p	u
9. Supplies, General (Dumps and Depots)	p	e	p	f	g	u	f	g	u
10. Supply Depots (Military)	p	e	f	p	f	u	f	f	u

See Footnotes at end of Table

[redacted]

TABLE XLIII (*Continued*)

TARGETS	TARGET[1] SUIT-ABILITY	ATOMIC WEAPONS EFFECTIVENESS TYPE OF BURST				
		A	G	UG	UGS	UW
III. Miscellaneous:						
1. Cities, Towns and Built-up Areas	e	e	g	p	f	u
2. Communication Center (Surface)	n	e	[illegible]	g	e	u
3. Dams and Levees	g	[illegible]	p	p	p	e
4. Headquarters and Camps	e	e	f	p	f	u
5. Mineable Areas	n	n	n	n	n	u
6. Power Plants, Hydroelectric	n	p	p	g	g	n
7. Power Plants, Thermo-electric	n	f	p	g	g	u
8. Radar Sites	n	e	g	e	e	u
9. Rocket Launching Sites	n	n	n	n	n	u
10. Seaplane Bases	e	f	p	p	f	f
11. Submarine Pens	e	n	n	f	f	n
12. Submarines, surfaced	p	f	e	u	u	e
13. Submarines, submerged	p	n	n	u	u	e
14. Transformer Substations	n	g	g	g	g	u

[1] Estimated in agreement with CGSC, Fort Leavenworth.
[2] Applies equally to Armor, Artillery, et cetera.
[3] Because of the complex nature of port functions, the effect of atomic weapons is controversial. The present a is not final.

TABLE XLIV
TABULATION OF ESTIMATES OF THE MILITARY WORTH OF TARGETS

TARGET	ORGANIZATION								
	Air Force	Sandia			Operations Research Office				
	TYPE WEAPON								
	A	A	UW	RW	A	G	UG	UGS	UW
I. Forces:									
A. Infantry:									
1. Airborne Assault Staging Area	s	y	y	y	e	g	g	e	n
2. Airheads	d	d	n	d	g	g	p	g	n
3. Amphibious Assault Staging Area	s	y	y	y	e	g	f	f	e
4. Amphibious Landing	d	y	y	y	e	g	f	f	e
5. Billets	d	d	..	y	f	f	p	f	u
6. Command Posts	..	d	..	y	n	f	g	g	n
7. Defiles (Troops)	..	d	d	d	g	f	f	g	n
8. Fixed Fortifications	u	d	d	y	n	n	f	f	n
9. Infantry (Offensive)	..	d	n	y	e	g	f	f	n
10. Infantry (Defending light fortification)	..	d	n	y	[illegible]	f	f	f	n
11. Troop Assembly Areas	s	y	..	y	e	f	f	f	n
B. Armor:									
1. Tanks	..	..	..	..	f	g	f	f	n
C. Artillery:									
1. Artillery (manned)	..	y	y	y	[illegible]	g	f	f	u
2. Artillery (equipment)	..	..	..	[illegible]	f	f	f	f	n
D. Tactical Air:									
1. Airfields	s	d	y	y	f	f	g	g	n

[redacted]

TABLE XLIV (*Continued*)

TARGET	ORGANIZATION									
	Air Force	Sandia			Operations Research Office					
	TYPE WEAPON									
	A	A	UW	RW	A	G	UG	UCS	UW	RW
II. Logistics:										
A. Transportation:										
1. Barge Concentrations	d	.	.	..	n	n	n	n	n	n
2. Canal Locks	u	d	d	d	p	p	f	f	p	n
3. Highway Bridges and Viaducts	u	d	d	d	f	g	g	g	n	n
4. Highway Right of Way	u	d	d	d	n	n	[illegible]	n	n	n
5. Motor Vehicle Repair Facilities	s	..			f	p	p	p	n	p
6. Port Areas	s	y	y	y	f	f	f	f	f	n
7. Railheads	s	n	n	n	n	n	n	n	n	n
8. Railroad Bridges and Trestles	u	d	d	d	p	g	g	g	n	n
9. Railroad Maintenance and Repair Shops	s		.	..	g	p	p	p	n	n
10. Railroad Marshalling Yards	s	n	n	n	p	p	p	f	n	n
11. Railroad Right of Ways	u	d	d	d	n	n	n	n	n	n
12. Railroad Transfer Points	u	d	d	d	p	f	f	f	n	f
13. Shipyards, Naval Operating Bases	s	y	y	y	g	p	p	p	p	n
14. Tunnels	u	d	d	d	n	n	g	g	n	n
15. Vehicles and Equip. Assembly Areas	s	..	..	..	g	f	p	f	n	f
B. Storage:										
1. Ammunition depot	u	d	d	d	p	p	p	p	n	n
2. Gas Dump (POL)	u	d	d	d	f	f	f	f	n	f
3. Oil Refineries	s	.	..	..	f	f	g	g	n	n
4 Oil Storage Tanks	s	.			g	f	g	g	n	n
5. Pipelines and Pumping Stations	u	d	d	d	n	p	p	p	n	n
6. Port Depots	s	y	y	y	f	n	f	f	f	n
7. Reservoirs and Aqueducts	u	.	.	.	n	p	p	p	n	n
8. Solid Fuel Storage	u	d	d	d	p	p	p	p	n	n
9. Supplies (General) (Dumps and Depots)	.	d	d	d	f	p	p	p	n	n
10. Supplies Depots (Military)	s	d	d	d	f	p	p	p	n	p
III. Miscellaneous:										
1. Cities, Towns and Built-up Areas	.	..	.	..	e	g	f	f	n	f
2. Communication Centers	.	d	d	d	n	n	n	n	n	n
3. Dams and Levees	u	.	..	.	n	p	p	p	g	n
4. Headquarters and Camps	s		..	..	e	f	f	f	n	f
5. Mineable Areas	u		..	.	n	n	n	n	n	n
6. Power Plants (Hydroelectric)	s	.		..	n	n	n	n	n	n
7. Power Plants (Thermoelectric)	s			.	n	n	n	n	n	n
8. Radar Sites	u				n	n	n	n	n	n
9. Rocket Launching Sites	u	.		.	n	n	n	n	n	n
10. Seaplane Bases	s		..		f	f	f	f	f	n
11 Submarine Pens	u		..	..	n	n	f	f	n	n
12. Submarines, surfaced	s	n	n	n	p	f	n	n	f	n
13. Submarines, submerged	u	n	n	n	n	n	n	n	f	n
14. Transformer Substations	u	.	.		n	n	n	n	n	n

[redacted]

volved in this target are limited in number, they are leaders, and the post itself is the nerve center for communications and controls.

Defiles.—A "good" target for an air burst or underground burst with surge. The target is of importance but the effectiveness of the weapon is limited by the linear nature of the target.

Fixed Fortifications.—A "fair" target for an underground burst atomic weapon, preferably with a base surge. This weapon is the one which will have appreciable effect on this target.

Infantry (Offensive).—An "excellent" target for an air burst atomic weapon. The infantry, concentrated for an attack and moving up, are not only a serious threat but are themselves vulnerable as they cannot be "dug in." Coordination and accuracy are very important since friendly troops must not be exposed.

Infantry (Defending Light Fortification).—Radiological material would have its most effective application against a target of this sort. Obviously radiological weapons do not destroy a target, but can be expected to make a given position unuseable. Otherwise, this target is "fair" for an air, ground or underground burst.

Troop Assembly Areas.—An "excellent" target for an air burst atomic weapon since the troops would be concentrated in the open.

FORCES—ARMOR

Tanks.—A "good" target for a ground burst weapon, and a fair" or somewhat less effective target for either an air burst or underground weapon.

FORCES—ARTILLERY

Artillery (manned).—An "excellent" target for an air burst weapon not only because of the great importance of the artillery fire to ground operation but because of the vulnerability of artillery personnel as now organized.

Artillery (equipment).—A "fair" target for an air, ground, or underground burst. Again the artillery fire is important but this is somewhat overcome by the invulnerability of the piece itself

FORCES—TACTICAL AIR

Airfields.—A "good" target for an underground burst. Tactical air support is of extreme importance to ground operations and an underground burst will inactivate an air strip.

LOGISTICS—TRANSPORTATION

Barge Concentrations.—A target of no value. Although an underwater burst and a ground burst are effective, the target has no importance to military operations.

Canal Locks.—A "fair" target for an underground weapon. The importance attached to this target is somewhat qualified.

Highway Bridges and Viaducts.—A "good" target for a ground or underground burst. A ground burst is here rated on a par with the underground burst because of the vulnerability of bridges to lateral forces.

Highways.—Of no military worth primarily because of the ease with which any obstacles may be detoured or the road repaired. Further, no weapon effect is rated better than "poor."

Motor Vehicle Repair Facilities.—A "poor" target for an air burst atomic weapon. Although the target is vulnerable, these facilities are plentiful and mobile, thus the importance of such targets is poor.

Port Areas.—A "fair" target for all types of atomic bursts. The military worth is limited by the weapons effectiveness despite the importance of such a target. It is believed that damage to shore facilities will hinder but not stop unloadings and that contamination will require movement and rotation of personnel. Effects on this target are controversial.

Railheads.—Of no military value because of the ease with which they may be moved. Such damage as may result from an underground burst is limited.

Railroad Bridges and Trestles.—The analysis is identical to that for highway bridges.

Railroad Maintenance and Repair Shops.—A "good" target for an air burst primarily because of the destruction of facilities in limited supply. This destruction is modified by the importance of the target in arriving at the military worth.

[redacted]

Railroad Marshalling Yards.—A "fair" target for an underground burst. Despite the effective result of the use of this weapon against this target, the large number of such yards and the possibilities of rerouting restrict their military worth.

Railroad Lines.—Of no value; similar to highways.

Railroad Transfer Points.—A "fair" target for a ground or underground burst. Such importance as is attributed to the target is because such points are few, and the flow of men and materiel depends upon them.

Shipyards—Naval Operating Bases.—A "good" target for an air burst atomic weapon because of the effectiveness of the burst on ships and essential facilities as well as the importance of such targets to military operations.

Tunnels.—A "good" target for an underground atomic burst. An underground weapon is the only one that can destroy a tunnel. The good effect of the weapon is combined with the importance of the target.

Vehicles and Equipment Assembly Areas.—A "good" target for an air burst primarily because of the effectiveness of the weapon against it as well as the importance of the target.

LOGISTICS—STORAGE

Ammunition Depots.—A "poor" target for air, ground, or underground weapons not only because of the limited effect of the weapons upon ammunition but because of the slight importance attached to a single depot.

Gasoline Dumps.—A "fair" target for an air, ground, or underground burst. Like an ammunition depot, it is of little importance but is somewhat more vulnerable to weapons effects.

Oil Refineries.—A "good" target for underground bursts both from weapons effectiveness and target importance

Oil Storage Tanks.—A "good" target for air or underground bursts; of less importance than refineries but more vulnerable.

Pipelines and Pumping Stations.—A "poor" target for ground and underground weapons because of invulnerability and ease of repair.

Port Depots.—A "fair" target for all types of atomic bursts. The military worth is limited by the weapons effectiveness despite the possible importance of such storage facilities.

Reservoirs and Aqueducts.—A "poor" target, largely because of the small importance attached to such targets. Underground weapons are, however, quite effective.

Various Dumps and Depots.—At best, "fair" targets for air burst weapons. Single dumps or depots are of relatively little importance.

MISCELLANEOUS

With few exceptions the targets listed in this category are of no military worth primarily because of the negligible importance attached to them. Notable exceptions are: *Cities and Built-up Areas* and *Headquarters and Camps* both of which are "excellent" targets for an air burst atomic weapon from both importance and weapon effectiveness; *Dams and Levees* a "good" target for an underground burst; *Seaplane Bases* a "fair" target for air, underwater or an underground burst with surge; and *Submarine Pens* are "fair" targets for underground bursts.

COMPOSITE TARGET ANALYSIS

In the next phase of target analysis situations will be considered in which are included various combinations of targets including those evaluated in the previous section. One type of analysis might be to determine the feasibility of destroying all the storage facilities, or all the railroad facilities, or all personnel of a certain type. It must be considered valuable to examine as many as possible such composite targets. As an initiation to such work it has been deemed profitable to attempt an analysis of the various types of functioning components composing ground forces as evidenced in the categories of Forces: infantry, armor, artillery, tactical air; and Logistics: transportation, storage. Tables XLII and XLIV are so composed. A preliminary evaluation of the profit of using atomic weapons on these various components can be obtained by even a cursory examination of Table XLIV. The limitations of this table for such analysis are evident. This is not a complete list of all the individual targets composing infantry, artillery or any of the rest. Nothing

is said of the number of such targets which would have to be considered and, short of setting up a complete field situation, very little can be said of the relative importance of destroying any combination of targets. Indeed it is evident that it will be necessary to assume various field situations, analyzing each in great detail before dependable conclusions can be formulated. ORO proposes to undertake such an analysis in the immediate future.

Meanwhile, much can be gained by examining the evidence in Tables XLIII and XLIV. Table XLV summarizes this information by considering only the letter of merit of the *best* kind of burst of attacking each target. Under *Forces,* for 11 out of 15 targets, an atomic weapon can be used with "good" or "excellent" results. Under *Logistics,* however, for 17 out 25 targets there is no weapon which is better than "good". Infantry seems to be a good target. Armor is at best a fair target and it is noted here that this occurs only for a ground or underground burst for which the area of damage is relatively small. Artillery is vulnerable, it is suggested here, because artillery*men* and communications are vulnerable. Tactical air is a good target if an underground explosion will weaken the substructure or will produce a displacement changing ground contours over a large area.

For the sake of completeness, of the original 54 individual targets, those not classifiable as either Forces or Logistics are listed in Table XLV under "Miscellaneous". The rather small military worth of these targets is merely indicative of the general nature of the targets. Cities and built-up areas and headquarters and camps are excepted.

To support the foregoing considerations, the components of Forces and Logistics will be discussed.

FORCES

INFANTRY

It is difficult to determine the suitability of infantry maneuvering in the field as a target for atomic weapons. A certain number of infantrymen having been determined as a suitable target for an atomic weapon, it may then be stated axiomatically that when any body of infantry exceeding this number is observed, there is presumably little difficulty in a decision to use an atomic weapon. If one atomic bomb would inflict 50 percent casualties on one division of infantry, an arbitrary judgment might be made that the use of an atomic weapon would be very profitable. Indeed, if it could be assumed that 50 percent casualties could be inflicted on 100 divisions of infantry with 100 atomic weapons, such a use would be decisive. In actuality, a deployment of infantry in the field is such that such a concentration is seldom realized. The number of atomic weapons required to cause 50 percent casualties within a division of infantry depends on the type of operation, i.e., offensive or defensive, kind of fortification and, most im-

TABLE XLV
COMPOSITE TARGET ANALYSIS, FUNCTIONAL BREAKDOWN

TYPE OF TARGET	NUMBER OF TARGETS	MILITARY WORTH OF TARGET ATTACK BY MOST EFFECTIVE WEAPON [1]				
		e	g	f	p	n
I. Forces:						
Infantry	11	5	4	2	0	0
Armor	1	0	0	1	0	0
Artillery	2	1	0	1	0	0
Tactical Air	1	0	1	0	0	0
	15	6	5	4	0	0
II. Logistics:						
Transportation	15	0	6	5	0	4
Storage	10	0	2	4	4	0
	25	0	8	9	4	4
III. Miscellaneous	14	2	1	4	0	7

[1] e=excellent, g=good; f=fair; p=poor; n=no good.

[redacted] Act - 1946
Clearance Not Required
[redacted] Safeguards

portantly, upon particular field situations which are radically different.

If the principle of dispersal is applied, then the analysis must involve a determination of how large the interval between infantrymen *can* be made as opposed to how large it *must* be made so that an atomic weapon may not be used profitably. It is judged that the present spacing of approximately 15 yards between infantrymen is the maximum spacing that will allow the necessary communication. The first effect of a judgment that on the average under operational conditions infantrymen are a suitable target for atomic weapons would be to reanalyze the possibility of greater dispersal of the infantry involving individuals, platoons or perhaps regiments. A preliminary judgment based on existing reports is that if 3 to 5 weapons could be suitably aimed at a division of infantry, the resulting damage would leave the entire division incapable of defense or, would effectively counter an offensive by such a force. On the other hand, infantry can be rendered nearly invulnerable to an air burst by suitable defense measures, strong fixed fortifications in particular. It should be emphasized here that infantry is a relatively fast moving target. Even if intelligence information determined that a suitable body of infantry had been located, the weapon would have to be used very quickly to reduce the chance that, even if aimed properly, it would not fall on the target.

It is possible to make an exhaustive and detailed analysis of the vulnerability of infantry to atomic weapons for the various types of field operations. This has not been done anywhere to date but such an analysis is to be started immediately at the Operations Research Office. Meanwhile a preliminary judgment, which is considered quite realistic, is that the use of atomic weapons on maneuvering infantry in the field should be planned.

ARMOR

Contrary to a widespread opinion that armor is quite invulnerable to an air burst atomic bomb, current studies in progress at ORO give indications that for appreciable distances from an air burst significant numbers of deaths and incapacitations may be inflicted on personnel inside tanks by the nuclear radiation, principally gamma rays, penetrating the tank walls; also that for appreciable distances the blast effects may be sufficient to move the tank with sufficient acceleration to produce personnel casualties and material damage. It is also thought that if the height of burst were reduced, or if the burst were on the ground the area of personnel and material damage may be increased. These results are purely tentative, pending further study. Analysis may, therefore, show that atomic weapons burst either in the air or on the ground may be used profitably against certain concentrations of tanks.

ARTILLERY

A rather more complete analysis will be made of the effect of atomic weapons on artillery. There is considerable evidence that artillery is highly vulnerable to an air burst atomic bomb, and, indeed, one atomic bomb can reduce the (artillery) fire power of a division enormously and make the entire division highly vulnerable to conventional weapons and methods of attack.

In the decision to use atomic weapons against artillery the following factors are important:

1. Importance of artillery;
2. Target presented by artillery;
3. Effect desired;
4. Comparison with other means of neutralization.

It is shown that an air burst is the most effective use of an atomic weapon against artillery. Other forms of atomic weapons have specific limitations which become apparent from this analysis.

1. *Importance of Artillery.*—The artillery is generally recognized as being indispensable to both the attack and the defense of any contended position. Its mission, as stated in Army Field Manuals, is "to furnish close and continuous fire support by neutralizing or destroying those targets which threaten the success of the supported infantry, by neutralizing or destroying hostile artillery, firing on hostile reserves, restricting movement in hostile rear areas, and disrupting hostile command agencies." Without this support and

in the face of opposing artillery fire, no position can be reasonably defended and attack is out of the question.

2. *Target Presented by Artillery.*—The frontage of an US infantry division is nominally 10,000 yards on the defense and from 3,000 to 5,000 yards on the offense. The dis-

position of the 3 infantry regiments an[illegible]fantry regiments and the 4 organic artillery battalions per divisio[illegible]battalions per division are shown in Figure 35 of a sector with a 3-di[illegible]of a sector with a 3-division front. It will be observed that 2 of the[illegible]bserved that 2 of the 3 infantry regiments divide the division fr[illegible]ivide the division frontage and extend to a depth of 3,000 to 4,000 [illegible]pth of 3,000 to 4,000 yards, tending to the greater depth when [illegible]eater depth when on de-

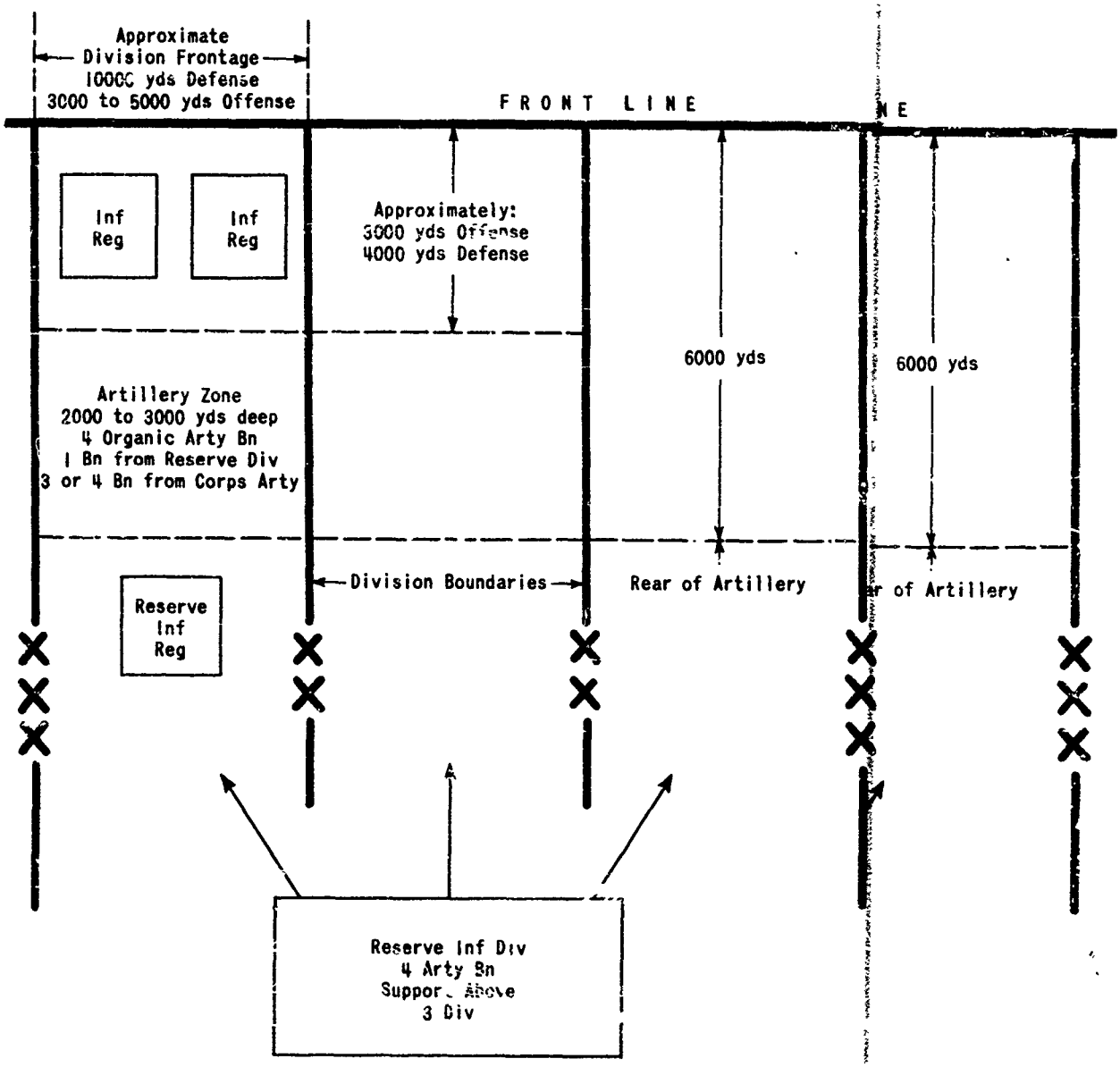

Figure 35.—Artillery Supporting a US Infantry Division

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fense. The artillery battalions are located behind the 2 front infantry regiments and extend back to 6,000 yards. The third infantry regiment is held in reserve behind the artillery.

In a normal situation an artillery battalion of a reserve division, as well as 3 or 4 artillery battalions of the corps artillery, will be emplaced in the 2,000- to 3,000-yard section with the organic artillery battalions of each of the 3 front line divisions. Thus, in the ordinary defensive situation, 8 or 9 artillery battalions and about 5,300 troops may be expected to be found in a band 2,000 yards wide and 10,000 yards long. The corresponding offensive artillery zone is about 3,000 yards wide and 3,000 to 5,000 yards long. Since each battalion has approximately 54 guns, a concentration of approximately 400 guns will be found per division front, i.e., in from 1.7 to 6 miles.

In contrast, the Soviets are believed to have a normal offensive concentration of 300 guns per mile which is appreciably greater than the most dense US concentration. However, the Soviet artillery zone extends somewhat farther back than does the US artillery zone. This is possible not only because of heavier Soviet artillery, but because a typical Soviet advance is along a wide front, but slow and with a limited objective. Thus, the artillery does not have to be up close at the start of an advance, as does US artillery, in order to provide artillery support ahead of the advance. However, in accordance with present military concepts, artillery committed to fire cannot further be dispersed and remain effective. Dispersion in depth is not possible, as the effective range and coverage of a piece is compromised. Lateral dispersion along the front is no solution either for the Soviets or ourselves. In Soviet tactics, involving an advance over a wide front, lateral dispersion could support only a limited area at each end of the advance. In US tactics artillery from battalions adjacent to the smaller attacking front are at present diverted to support the attack so that, in effect, no greater dispersion can be realized.

3. *Effect Desired.*—The effective neutralization of artillery is not accomplished by destroying the artillery piece itself, though this would be desirable. Unlike personnel and buildings, an artillery piece itself is relatively immune to an atomic weapon as it is also relatively immune to high explosives. However, effective fire from artillery is the end product of a necessary and well integrated chain of events. The individuals responsible for this fire extend from the observation post, the battalion command post, the fire control station, to the gun crew itself, and each of these positions requires close radio or phone communication to produce effective fire. The individuals involved are highly skilled. Although relief crews are maintained, they are the extent of the "reserve artillery" and will be found in the artillery zone when not on duty. To simplify: although a reserve infantry division is generally maintained, "artillery is held in reserve *only* when the situation is so obscure that the sector in which the bulk of the artillery fire power will be needed cannot be foreseen." (The Soviets, partly because of special limitations at a front as well as their emphasis on infantry and artillery, have artillery divisions as well as infantry divisions which are actually held in reserve.)

It follows from the preceding that the desired effects on artillery as a target are the destruction of the trained personnel and the disruption of the fire control system. This can best be accomplished by an air burst. Such damage as will occur to these artillery pieces sufficiently close to ground zero is secondary. It should be realized, however, that although an artillery piece is built to withstand the shock and recoil of "fire", random shock may well be expected to damage carriage, mechanisms, and sights.

Surprise in an atomic attack against artillery is important. It is estimated that an air burst would kill 50 percent of the personnel within the *open* lethal radius of the bomb and would effectively eliminate from 2 to 4 artillery battalions and reduce the effectiveness of even more. Even were the error of delivery approximately 1,000 yards so that ground zero was not centered in the artillery zone, one-half of the artillery mentioned previously would be eliminated plus some infantry battalions. In any event, the fire control system would be disrupted, and would re-

main so at least until radios could be brought in and the network re-established.

The importance of artillery as a target is brought out further by detailed comparison with an infantry regiment. Because of general training in infantry, if 50 percent of the personnel are lost, there still remains one-half an infantry regiment which could be expected to do about half the job of the whole regiment, not considering the effect on morale. In contrast, if 50 percent of an artillery battalion is lost, then it must be assumed that one-half of the skilled, key personnel are lost and, missing these vital links in the sequence leading up to fire, the effectiveness of the artillery is reduced to nil. Further, infantry is generally held in reserve, whereas artillery seldom is.

4. *Other Means of Neutralization.*—The effectiveness of other means of neutralizing artillery is dramatically illustrated by the casualty figures from the past war. In an infantry division 93 percent of the casualties were among the infantry regiments; only 2.4 percent were among the artillery battalions. To show the pro rata incidence of casualties these figures would have to be corrected, since there are three times as many infantrymen as artillerymen. Even so, it appears that there is no other really effective weapon for the destruction of artillery. Largely because of this fact, reserves and replacements for artillery personnel were (and still are) a very minor consideration.

5. *Conclusions.*—(a) Artillery is a good target, particularly as now organized (b) Recommendations for defense:

(1) Dig in deeper;

(2) Evacuate relieved gun crews from vicinity of pieces;

(3) Increase "cross-training";

(4) Maintain mobile artillery reserves;

(5) Train more replacement personnel;

(6) Develop longer range artillery to effect dispersion;

(7) Protect fire control system;

(8) Add reserve artillery battalion to each division.

TACTICAL AIR

A complete analysis of the vulnerability of tactical air to atomic weapons will not be made here since this is an Air Force problem. However, the importance of tactical air support of ground operations is such that it is necessary to assess the vulnerability of tactical air in order that an analysis of the functioning of a field army may be made. Studies have already been made which indicate that an air burst atomic bomb is highly effective against air fields. The effect, of course, is to damage the hangar and repair facilities, to destroy standing aircraft within a large radius, and to kill any exposed personnel. However, the analysis also shows that use of the runways is not denied for a period longer than about 10 days. It is, therefore, necessary to use atomic bombs periodically in order to keep a tactical air force from operating effectively. According to existing estimates, a large number of atomic bombs, approximately 500 to 1,000 per month, would be required to keep the Soviet tactical air force within a distance of 500 to 600 miles of the Rhine from operating. Even the prime necessity of attaining air superiority does not suggest that such a large number of atomic bombs could be so used.

There is, however, a possibility that other types of atomic weapons could be built which would actually deny the use of the air fields for longer periods of time. For example, a penetrating type of atomic bomb with jets might so weaken the subgrade and soil structure of an air field that a strip could not profitably be repaired to support heavy aircraft. Again, there is the possibility that an atomic bomb exploded 100 feet or more underground would, in addition to producing a crater 500–1,000 yards in diameter, produce sufficient earth movement in the vicinity to destroy the runways. Great emphasis should be placed on determining the effects of underground burst. Indeed, if the preceding two effects are possible, such a weapon would be of tremendous importance in its utility in denying use of tactical air fields for long periods of time.

LOGISTICS

SOVIET LOGISTICS

Currently much effort is being directed toward examination of the Soviet logistics sys-

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tem. It is not the purpose here to present a complete and detailed analysis of all the information that is available. An attempt, however, will be made to point out the limitations of knowledge and the implications of some of the information upon which there is general agreement. It is believed that the Soviet logistics system is more vulnerable to attack than our own, predominantly because there is less tendency to stockpile in either the communications zone or combat areas. This policy not only enhances the value of Soviet transportational targets but storage facilities as well if and when they can be found. It will be shown here that, in spite of this, Soviet logistics are not suitable for attack by atomic weapons but rather for attack using other conventional means. A running discussion of Soviet logistics will be given, starting at the front line area.

Supplies of all kinds are certainly stockpiled in the combat area. It can be assumed that if dumps or depots in the combat area are sufficiently large, they would be good targets for an air burst atomic bomb. There is, however, no evidence using information derived from either the Soviets or from the Germans that during the last war the forces of the USSR constructed dumps or depots of such a size in the combat area. This is not to say that such dumps or depots did not exist. There might have been a few. It is more reasonable to believe, however, that there would be a tendency to construct a large number of small dumps rather than a small number of large dumps. Until evidence is obtained that the Soviets plan to concentrate supplies in dumps sufficiently large and of a sufficiently critical nature to be judged a suitable target for an atomic weapon, it is impossible to predicate a requirement for atomic weapons on a need to use them against such targets. However, even small dumps and depots when they are found during the course of a battle are suitable for attack by conventional means of one sort or another as, for example, by high explosives or incendiaries.

The system of roads and highways connecting dumps and depots in the combat area with the communications zone are not good targets for atomic weapons. Not only may damaged roads and highways be readily repaired but such damage is generally easily avoidable by short detours. Certainly on occasion it may be proper to use a suitably designed atomic weapon on the highway bridge or tunnel which for some reason is of importance. In general, however, it must be concluded that highways should not be attacked with atomic weapons. Although a truck convoy on a highway would be greatly damaged by an air burst atomic bomb, the importance of a truck convoy would not warrant the use of an atomic bomb. Here again, conventional means are very effective as, for example, strafing by tactical aircraft.

Soviet truck convoys originate at railheads and, certainly, an atomic bomb will knock out the facilities at a railhead. However, in general, railheads are not of great enough importance, since the effect would be merely to move the railhead farther back along the railroad. Railroads themselves cannot be cut with an air burst atomic bomb. It is true that railroad bridges and tunnels may occasionally be of sufficient importance to warrant their being knocked out at almost any cost.

Marshalling yards and transfer points are in some respects good targets. An air burst would destroy rolling stock and maintenance and repair facilities. Certainly there would be many personnel casualties. An air burst, however, will not deny the use of a transfer point or marshalling yard for a great length of time. There is an exception to this in that an underground burst with base surge might contaminate a marshalling yard so that it would not be profitable to use it. Here again the profitability of using an atomic weapon would have to be on the basis of the importance of the marshalling yard or transfer point. In central Europe there is a marshalling yard in almost every small city and it has been pointed out that it is usually possible to shunt rolling stock around any particular point. It is possible that a complete analysis would indicate that with a limited number of atomic bombs a sufficient number of marshalling yards and other railroad facilities could be temporarily denied in such a way that the whole Soviet railroad transportation system

would break down. Such an analysis has not yet been made, and at the present time it must be assumed that railroads and railroad facilities of all sorts are not profitable targets for atomic weapons.

In conjunction with the railroad system in the communications zone, supplies of all sorts are maintained in depots and dumps. Taking a very narrow point of view, if the line of the Rhine is held, then East Germany and perhaps western Poland will compose the Soviet communications zone. At the present time it is known (Special Intelligence Summary, Intelligence Division, Headquarters, European Command, 1 November 1949, No. 48, D-2628) that hundreds of Soviet depots are now maintained in this area. It is considered that the intelligence information with reference to these depots is very reliable. However, of the hundreds of depots, an exceedingly small number are large enough to be suitable targets for atomic weapons. If depots of sufficient importance exist or will exist in the Soviet communications zone, there is no evidence in the intelligence now available.

Insofar as the zone of the interior is concerned, there is again no intelligence with regard to the existence of depots which might be sufficiently large and of sufficient importance to warrant the use of an atomic weapon. It may be stated categorically that there are more important targets for atomic weapons in the Soviet zone of interior than the possibly existent supply depots. An over-all conclusion, therefore, qualified on the basis of the limitations of existing information, is that an attack on the Soviet logistics system should not be planned using atomic weapons. If logistics are divided into components of transportation and storage, it is concluded that storage facilities are slightly better targets for atomic weapons than are transportation facilities. This conclusion is reached not only because of the relatively larger area of the storage facilities as compared to the transportational facilities but because of the existence of a well integrated transportation network which permits re-routing and shunting of carriers.

US LOGISTICS

With respect to the defense of western Europe the US logistical problem is much more difficult than that of the Soviets, primarily because of the severity of the problem imposed by an intervening ocean. However, much of what has been said about the Soviet logistics system will apply to our own.

Although there were situations in World War II in which there existed depots and stockpiles of supplies and equipment of all sorts which would have made excellent targets for an air burst atomic bomb, there is no evidence that dispersal would not have made these unsuitable targets. In fact, if one applies the criterion of dollar value of material destroyed compared with dollar value of an atomic bomb delivered to the target, and assume that the latter value is approximately $2,500,000, it is immediately evident that depots and dumps the total value of which is greater than the preceding amount need not be constructed. Of course, there is much more involved in the decision that a target is worth an atomic bomb than the relative value.

Ports and port areas are a unique problem of US logistics. No attempt will be made here to give a complete analysis of the profitability of knocking out the US logistics by denying the use of ports and port areas in Europe. Many agencies are already aware of the threat to our lines of communication if the Soviets can knock out the few large ports open to us. If, by any of the means available to the Soviets, these ports or any that we commit to large scale use are denied to us, the possibility of using many small ports and beaches becomes important. So far as is known, no realistic estimates attest the feasibility of passing supplies and equipment through small ports and beaches in quantities sufficient to support a major effort in western Europe. This is nevertheless the kind of problem for which a solution seems possible, even recognizing the difficult problems of unloading, handling, storage and transportation which are raised.

At any rate, it is important to know what damage atomic bombs can do to port areas. In some respects there is the possibility that the port can be denied for a long period of

time by the loss of vital handling equipment, local labor, and the sinking of ships in berths or vital passageways. In most respects, however, atomic bomb damage would not deny the use of the port for any great length of time. Certainly there would be great loss of ships, supplies and equipment aboard ship and stored in the area.

The best assumption, however, seems to be that with one means or another the Soviets can deny the US use of the small number of large ports and that it will be necessary for the US to rely on a large number of small ports and beaches. On the basis that there *must* be an adequate solution to the latter problem it is judged that, generally speaking, the US logistics system will not be a suitable target for Soviet atomic weapons.

REQUIREMENT FOR VARIOUS TYPES OF BURST

Even though the foregoing target analysis is qualitative and the merit assigned to individual targets may be changed as further work is done, the accumulation of evidence will indicate some trends which are significant. In this section the relative importance of the various types of burst and of radiological effects is analyzed.

Table XLVI is taken from Table XLIV and shows only the *best* type of burst for each target. Against 13 of the 54 individual targets no type of burst had any value, i.e., the best letter of merit was n.

Table XLVII, obtained from Tables XLIV and XLVI, summarizes all the target data under the three headings of number of targets for which the worth was (1) poor or fair, (2) good or excellent, and (3) the number of targets for which the type of burst was the best or tied for best.

AIR BURST VS GROUND BURST

The consideration here is whether or not the FM type of bomb should be provided with a proximity or contact fuze so that the explosion will occur between treetop height and the ground.

Individual Target Consideration.—Table XLVII shows that both air burst and ground burst have great effect on many targets. About two-thirds of the 54 targets have some worth for both air and ground burst.

An air burst is good or excellent for the following targets:

1. Staging areas for airborne assault;
2. Airheads;
3. Staging areas for amphibious assault;
4. Amphibious landings;
5. Defiles (troops);
6. Infantry (offensive);
7. Troop assembly areas;
8. Artillery (manned);
9. Railroad maintenance and repair shops;
10. Shipyards, naval operating bases;
11. Vehicle and equipment assembly areas;
12. Oil storage tanks;
13. Cities, towns, built-up areas;
14. Headquarters and camps.

A ground burst is good or excellent for targets 1, 2, 3, 4, 6, 8, and 13 on the preceding list. In addition, railroad and highway bridges, viaducts and trestles, and armor (manned tanks) may be suitable in special situations. It is noted here that bridges are probably good targets for a ground burst only when delivered by a guided missile with an accuracy of 200 ft circular probable error or better.

From Table XLVII, an air burst is best on 26 targets and a ground burst on 16. Nine targets are common to both.

Of the remainder, there are 7 targets for which a ground burst is both the best of all bursts and superior to an air burst. From Table XLVI these are:

1. Armor—good.
2. Highway bridges and viaducts—good.
3. Railroad bridges and trestles—good.
4. Railroad transfer points—fair.
5. Pipelines and pumping stations—poor.
6. Reservoirs and aqueducts—poor.
7. Submarines, surfaced—fair.

Armor will be discussed in the [illegible] section. Bridges, trestles, and viaducts have already been referred to, and the rest being either fair or poor will not be treated.

It is now possible tentatively to conclude that a proximity or contact fuze on an FM type atomic bomb is necessary (from the point of view of individual targets) *principally for*

bridges, trestles or viaducts. With the exception of these targets for all those armor taken into consideration in the preceding two lists, an air burst fuze will do everything that can be done by a ground burst and more.

Composite Target Consideration.—Now reference is made to composite targets to see if the foregoing conclusion (that a ground burst is not required) is consistent.

1. *Infantry*—ground burst not needed, air burst is much the better.

2. *Armor*—this is an exception. A ground burst is good and is the better type for armor. Should it become really important to use atomic weapons on armor, a ground burst would be preferable (the air burst is also effective but to lesser degree). The underground burst may also have bearing here and will be mentioned later.

3. *Artillery*—air burst is better.

4. *Tactical air*—air burst is better (underground *may* be best, as mentioned later).

5. *Transportation*—air burst is better, except for bridges. Allowance should be made for possibility that knocking out bridges with guided missiles may become important.

6. *Storage*—air burst is better.

It is concluded that except for armor and bridges there is no real necessity for a ground burst.

NECESSITY FOR UNDERGROUND OR UNDERWATER BURST

A penetrating type of weapon such as LC is needed for underground or underwater burst excepting, of course, for such weapons as delay action mines laid by craft which have not been considered here.

Individual Target Consideration.—Table XLVII shows that underground or underwater bursts may have great effect on many targets. An underground burst without a base surge has poor or fair worth for 33, good or excellent for 8, of the 54 targets, and is the best or as good as the best for 21 targets. With a base surge the underground burst is poor or fair for 31, good or excellent for 10, and is best or equal to best for 26 targets. The presence of a base surge increases the effectiveness and worth of an underground burst. Underwater burst with poor or fair worth for 7, good or excellent for only 3, and best or equal to best for only 8 targets is not as impressive as underground bursts, obviously, because the

TABLE XLVI
MILITARY WORTH OF TARGETS; SHOWING BEST BURST ONLY
(Selected from Table XLIV)

	MILITARY WORTH (ORO)					
	A	G	UG	UGS	UW	RW
I Forces:						
A. Infantry:						
1. Staging Areas for Airborne Assault	e		.	e	..	..
2. Airheads	g	g	..	g	..	..
3. Staging Areas for Amphibious Assault	e	..	..	..	e	
4. Amphibious Landings	e	..	.	.	e	
5. Cities	f	f	.	f	..	f
6. Command Posts		.	g	g	..	
7. Defiles (Troops)	g	..	..	g	.	.
8. Fixed Fortifications	.	.	f	f	.	
9. Infantry (Offensive)	e	.	.			.
10. Infantry (Defending Light Fortification)	f	f	f	f		f
11. Troop Assembly Areas	e	..		.		
B. Armor:						
1. Tanks	..	..	..			
C. Artillery:						
1. Artillery (Manned)	e	.	..	..	..	.
2. Artillery (Equipment)	f	f	f	f	..	.
D. Tactical Air:						
1. Airfields		.	g	g	.	

[redacted]

TABLE XLVI (*Continued*)

	MILITARY WORTH (ORO)					
	A	G	UG	UGS	UW	RW
II. Logistics:						
A. Transportation.						
1. Barge Concentrations	..	.	..	.	.	..
2. Canal Locks	..	.	f	f	..	..
3. Highway Bridges and Viaducts		g	g	g	..	.
4. Highway Right of Ways	..	..	..	..	..	..
5. Motor Vehicle Repair Facilities	f	.	.	.	..	.
6. Port Areas	f	f	f	f	f	..
7. Railheads	.	..	.	.	..	..
8. Railroad Bridges and Trestles	..	g	g	g	..	..
9. Railroad Maintenance and Repair Shops	g	.	.		..	..
10. Railroad Marshalling Yards	..	..		f	..	..
11. Railroad Right of Ways	..	.	.	..	..	.
12. Railroad Transfer Points	.	f	f	f	..	f
13. Shipyards Naval Operating Bases	g		.	..	..	..
14. Tunnels	.	..	g	g	..	..
15. Vehicles and Equipment Assembly Areas	g			.	..	..
B. Storage:						
1. Ammunition Depot	p	p	p	p	..	.
2. Gas Dump (POL)	f	f	f	f	..	f
3. Oil Refineries	.	..	g	g	..	..
4. Oil Storage Tanks	g	.	g	g	..	..
5. Pipelines and Pumping Stations	.	p	p	p	..	.
6. Port Depots	f	..	f	f	f	..
7. Reservoirs and Aqueducts	..	p	p	p	..	..
8. Solid Fuel Storage	p	p	p	p	..	..
9. Supplies, General (Dumps and Depots)	f	.	..	.	..	..
10. Military Supply Depots	f	.	.	..	..	..
III. Miscellaneous:						
1. Cities, Towns and Built-up Areas	e	..	..	..	..	..
2. Communication Centers	..	..	..	..	..	..
3. Dams and Levees	..	.	..	..	g	..
4. Headquarters and Camps	e	.	.	..	.	.
5. Mineable Areas	..			..	.	..
6. Power Plants, Hydroelectric	..	..	..	..	..	..
7. Power Plants, Thermo-electric	.		..	..	..	..
8. Radar Sites	..	..	.	..	..	..
9. Rocket Launching Sites	..		.	..	..	..
10. Seaplane Bases	f	f	f	f	f	..
11. Submarine Pens	..	.	f	f	..	..
12. Submarines, surfaced		f	.	.	f	..
13. Submarines, submerged	..	..	..	..	f	..
14. Transformer Substations	.	.	..	..	..	..
Total	26	16	21	26	8	4
Total Number of Targets	54	54	54	54	54	54

targets being considered are in most instances not near water.

It will now be assumed that air burst will be available but that ground burst *will not*. Further, it will be assumed that a requirement for underground or underwater burst will be considered as needed for only those targets not already determined highly vulnerable to air burst. That is to say, in Table XLVI only targets are now considered for which the best method is the underground or underwater burst and *not* the air burst. So, for example, airborne assault staging areas will not be considered since they have excellent worth for

TABLE XLVII
SUMMARY OF BURSTS

TYPE OF BURST	NUMBER OF TARGETS OUT OF 54 HAVING MERIT OF MILITARY WORTH INDICATED		
	(1) Poor or Fair	(2) Good or Excellent	(3) Best Effect
A	27	14	26
G	28	10	16
UG	33	8	21
UGS	31	10	26
UW	7	3	8
RW	17	0	4

both air and underground. Then referring to Table XLVI, the following targets are to be considered:

1. Command posts	good
2. Armor	good
3. Tactical air fields	good
4. Highway bridges and viaducts	good
5. Railroad bridges and trestles	good
6. Railroad transfer points	fair
7. Tunnels	good
8. Oil refineries	good
9. Pipelines and pumping stations	poor
10. Reservoirs and aqueducts	poor
11. Submarine pens	fair

This group includes some very important targets. At this point in the analysis the conclusion is that an *air burst alone will not destroy all important individual targets.* Two questions are pertinent to the decision to provide a penetrating weapon giving an underground or underwater burst:

1. What accuracy is required?
2. Should a penetrating type guided missile with an atomic warhead be developed?

These questions will be considered later in the study.

Composite Target Consideration.—The foregoing conclusion that the air burst does not solve all problems is substantiated by the following:

1. *Infantry*—inability to destroy command posts is not critical.
2. *Armor*—if armor *must* be attacked with atomic weapons, a ground burst is more effective than either an air burst or underground burst.
3. *Artillery*—air burst best.
4. *Tactical air*—*if* an underground burst will deny use of an air field for a long period of time as has already been discussed, then an underground burst is very essential even if applicable to this target
5. *Transportation*—of the targets involved, bridges and tunnels are most important and indicate a need for either ground or underground burst.
6. *Storage*—underground burst is important for oil refineries and submarine pens alone.

IMPORTANCE OF RADIOLOGICAL WARFARE

Table XLVI shows that radiological warfare has poor or fair worth with respect to 17 out of the 54 targets; on none is its worth good or excellent, but on 4 targets (billets, infantry in light fortifications, railroad transfer points, and fuel dumps) it is best, though on a par with other types of burst. In each instance the worth is only fair.

In view of this evidence it is difficult to conclude that radiological warfare has great utility in ground operations. However, it is recognized that this report, treating the subject in a manner similar to all other reports to date on this subject, has assumed that radiological warfare would not be available in sufficient quantities for denial of entry or passage but rather for harassment. At the present time it is beginning to be recognized that the development of production facilities in the next five years may make it possible to stockpile large quantities of radiological material and that ultimately the restriction will not be *How much can be produced?* but *What is the cost of production compared to its military utility?* It must be recognized that perhaps the outstanding difficulty encountered in evaluating radiological warfare stems from the strangeness of the concept to military thinking. *Destruction* of personnel and material is encountered with a feeling of familiarity but the concept of temporary denial to passage, entry, or occupancy is so unusual in military analysis as to require very careful consideration.

[redacted]
Specific [redacted]
Use [redacted]

ACCURACY OF DELIVERY

The problem of accuracy of delivery is very important. It has already been stated that the principal advantage of a guided missile with atomic warhead over high altitude bombing is in the accuracy of delivery. It has been stated that to obtain such accuracy, it is necessary to sacrifice some efficiency of explosion, which gives, in general, lower energies for a guided missile warhead than can be obtained in a bomb. Also, for some time to come guided missiles will be much more restricted in range than heavy bombers.

It is almost a truism that, other factors being equal, greater accuracy is to be preferred. On the other hand, situations can be imagined where this is not the case. Suppose, for example, that the radius of the target is very large as compared to both the damage radius and the error in delivery and that it is merely required to place the weapon so that the damage area is anywhere in the target area. Recognizably, there would be no necessity to reduce the delivery error below a certain value. Another example is that of a target of restricted dimensions and a damage radius for the weapon very large by comparison. Below a certain value of error in delivery there would be near certainty that the target area would be inside the damage area.

There is, in general, in connection with the employment of atomic weapons a requirement that only the enemy be damaged. In using these weapons in ground operations, application of this requirement necessitates examination of many situations and it will not be possible to give a simple accuracy requirement other than perhaps to state a maximum acceptable error.

Following the development of adequate mathematical formulation it is planned in this office to obtain quantitative solutions to these problems of accuracy. It is believed that qualitative thinking will in many situations lead to erroneous conclusions. Several examples will now be given using the mathematics which is already available to indicate some of the problems involved.

ASSUMED ACCURACY OF VARIOUS METHODS OF DELIVERY

Table XLVI shows the accuracies of the various delivery methods which are to be considered. It is emphasized that all accuracies except for high altitude bombing are estimated. Even the latter accuracy is extrapolated from proving ground and training figures; hence, what may actually be obtained under operational conditions is not known (known estimates go as high as 1,700 yards circular probable error for radar bombing).

HERMES A-1 VS RADAR BOMBING

Unquestionably there are many instances where Hermes A-1 with an accuracy of 100 yards circular probable error will give results far superior to radar bombing with an accuracy of 1,000 yards circular probable error. An example will be given here which, in pointing up some of the difficulties in a decision that guided missiles with atomic warhead must be developed, will suggest caution in premature judgments.

Two circular targets will be considered: (a) area 4.84 sq mi (radius 1.24 mi); and (b) area 10.3 square miles (radius 1.81 mi). It will be assumed that for these targets the damage areas of both the bomb and the missile are 4 square miles (damage radius, 1.13 mi). It will also be assumed that the energy of the bomb is about 40 KT, and that of the missile one-half this energy or the nominal 20 KT. In view of the first assumption, this energy relationship gives a bias in favor of the guided missile. Suppose it is required to know what percent coverage the weapon will have on the target *with near certainty*. A probability of 94 percent is used here which corresponds to the 2 circular probable error distance.

Circular Target, 4.84 sq mi

Number of Weapons Used	*Coverage with 94 Probability Percent*
1 bomb	44
1 Hermes A-1	85
6 bombs (aimed at same point)	94

Figure 24 is used to compute one bomb and one Hermes A-1. RAND Report (R-169), *Empirical Bomb-Coverage Distributions* (advance copy), was used to compute six bomb cases.

One Hermes A–1 is much better than *one* bomb but not so good as *six* bombs.

Circular Target, 10.28 sq mi	
Number of Weapons Used	*Coverage with 94 Probability Percent*
1 bomb	34
1 Hermes A–1	40
6 bombs (aimed at same point)	64

One Hermes A–1 is not significantly better than *one* bomb and *six* bombs are much better than *one* Hermes A–1.

Figures 36, 37, and 38, which are compiled using Figures 34, compare guided missiles, Hermes A–1 and Corporal E (assumed nominal 20 KT) with a bomb (assumed 40 KT) and with a 280mm artillery shell (assuming 1 KT and the nominal 20 KT) for circular targets of various sizes. Referring to Figure 36 for the case of 10 psi limiting damage, both guided missiles are superior to the bomb for targets up to 3,000 yards radius. For targets smaller than 2,000 yards radius, Hermes has a coverage of greater than 80 percent. Corporal E has a coverage of 80 percent or greater for targets less than 1,600 yards in radius.

For damage corresponding to 25 psi or greater (Figure 37) the guided missiles are better than the bomb for targets of all sizes. Hermes A–1 gives a coverage of 80 percent or better for targets up to 950 yards radius and Corporal E for targets up to only 400 yards. It is instructive to compare Hermes A–1 with Corporal E. For a target 700 yards in radius Hermes A–1 will cover the target with 25 psi damage or greater while Corporal E only covers 60 percent (all of this, of course, with a 94 percent probability that the damage will be that indicated or greater).

Finally, it is observed (Figure 38) that for large damage radii corresponding to damage produced by thermal radiation of 3 calories per sq cm (producing painful skin burns), Hermes A–1 is not as good, though comparable to, the bomb except for targets from 2,000 to 3,700 yards in radius.

It is not the intent here to introduce serious doubt that an atomic warhead should be developed for a guided missile. It is, however, suggested that only a complete analysis taking into account many factors will answer the question.

FIELD ARTILLERY (280-mm—1-KT) VS RADAR BOMBING

Figure 36 shows that a 40 KT atomic bomb is *always* better than a 280-mm shell of 1 KT for a damage area bounded by an overpressure of 10 psi. Both have less than 50 percent coverage. Figure 37 for 25 psi shows that although there is a range of target sizes for which the 280-mm shell (1 KT) is better than the bomb, neither exceeds a coverage of 10 percent. Cases where 10 percent coverage is adequate are assumed to be very rare. For damage corresponding to limiting overpressure values less than 10 psi, the bomb *always* gives more coverage than the 1 KT 280-mm shell except, of course, where the target is entirely in the damage area in which case both are 100 percent. This is borne out in Figure 38 for damage radii corresponding to painful skin burns (3 calories per sq cm thermal radiation). Further analysis may show that a low energy 280-mm shell may be needed when damage is to be restricted to a relatively small area, as to protect friendly troops. Again field artillery, being more an "all weather" method of delivery, invites analysis along that line. Until some demonstration of this sort is made, it should be assumed that a 40 KT bomb is better than a 280-mm shell of 1 KT and the latter *should not be developed.* Figures 36 and 37 also show, however, that a 280-mm shell of 20 KT would have a great advantage over the 40-KT bomb, and a weapon of this sort seems very much worth development. It is realized that the feasibility and cost of such a weapon must first be determined. It is not the purpose in this paper to give such an analysis but it is strongly recommended that this be done by the appropriate agency.

20–KT BOMB VS 80–KT BOMB

It is frequently pointed out that the damage radius of an atomic bomb increases only very slowly as the energy increases, as $W^{1/3}$ actually. However, as the energy increases from 20 to 80 KT, the radius of equivalent blast damage increases by 60 percent. That such an increase is important in attacking targets of finite size is indicated in Figure 39. For

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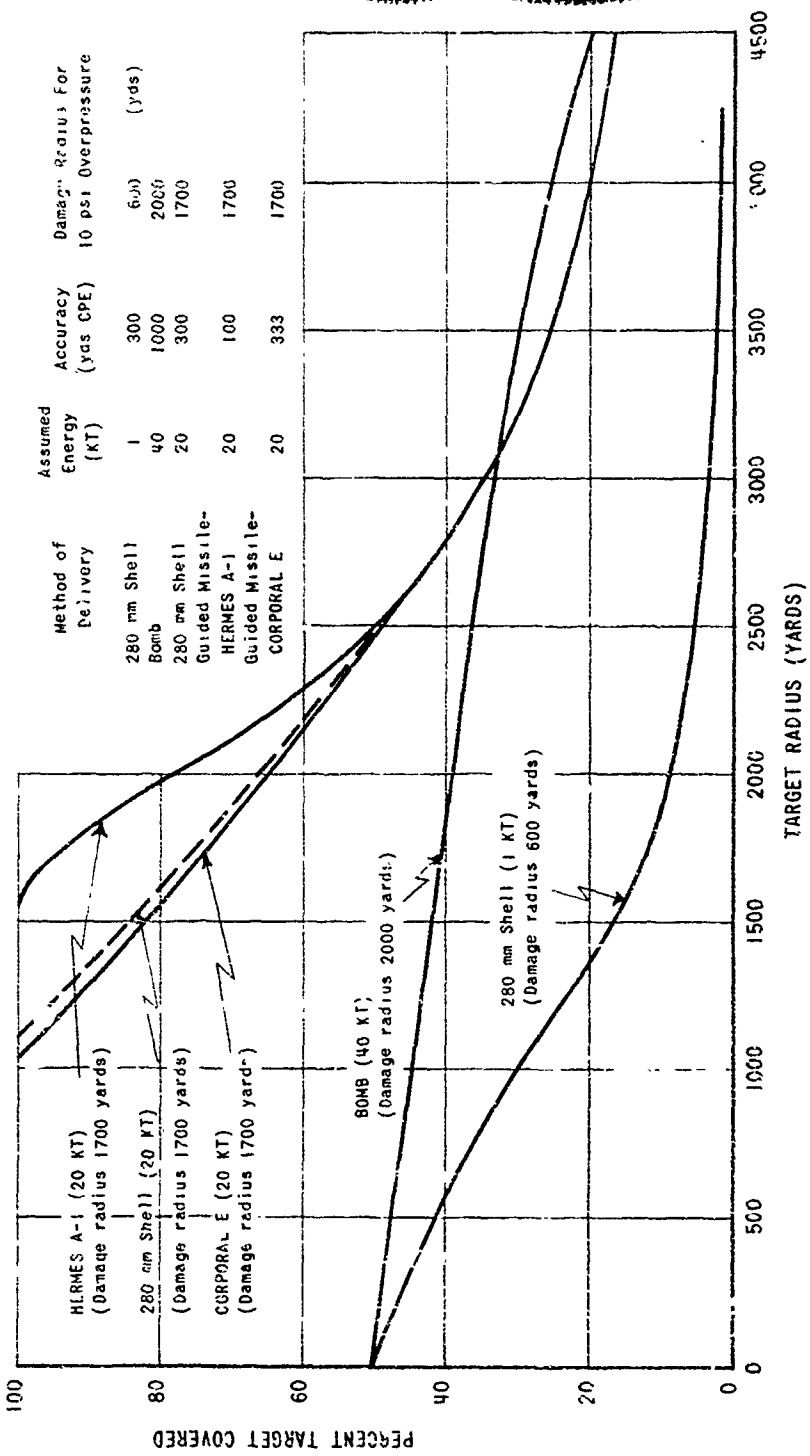

Figure 38.—Percentage of Circular Target Covered with .937 Probability vs. Target Radius

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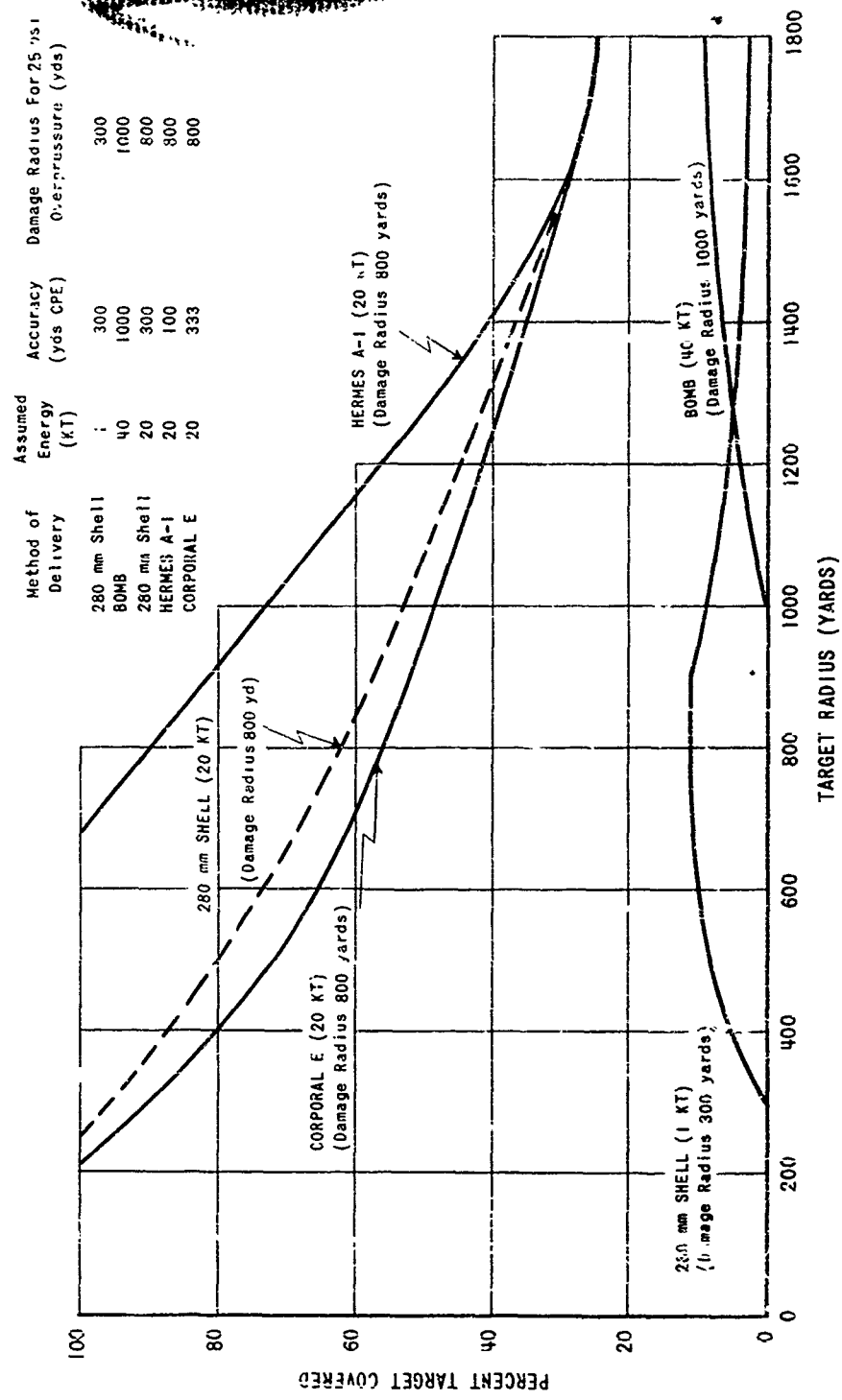

Figure 37.—Percentage of Circular Target Covered with .837 Probability vs. Target Radius

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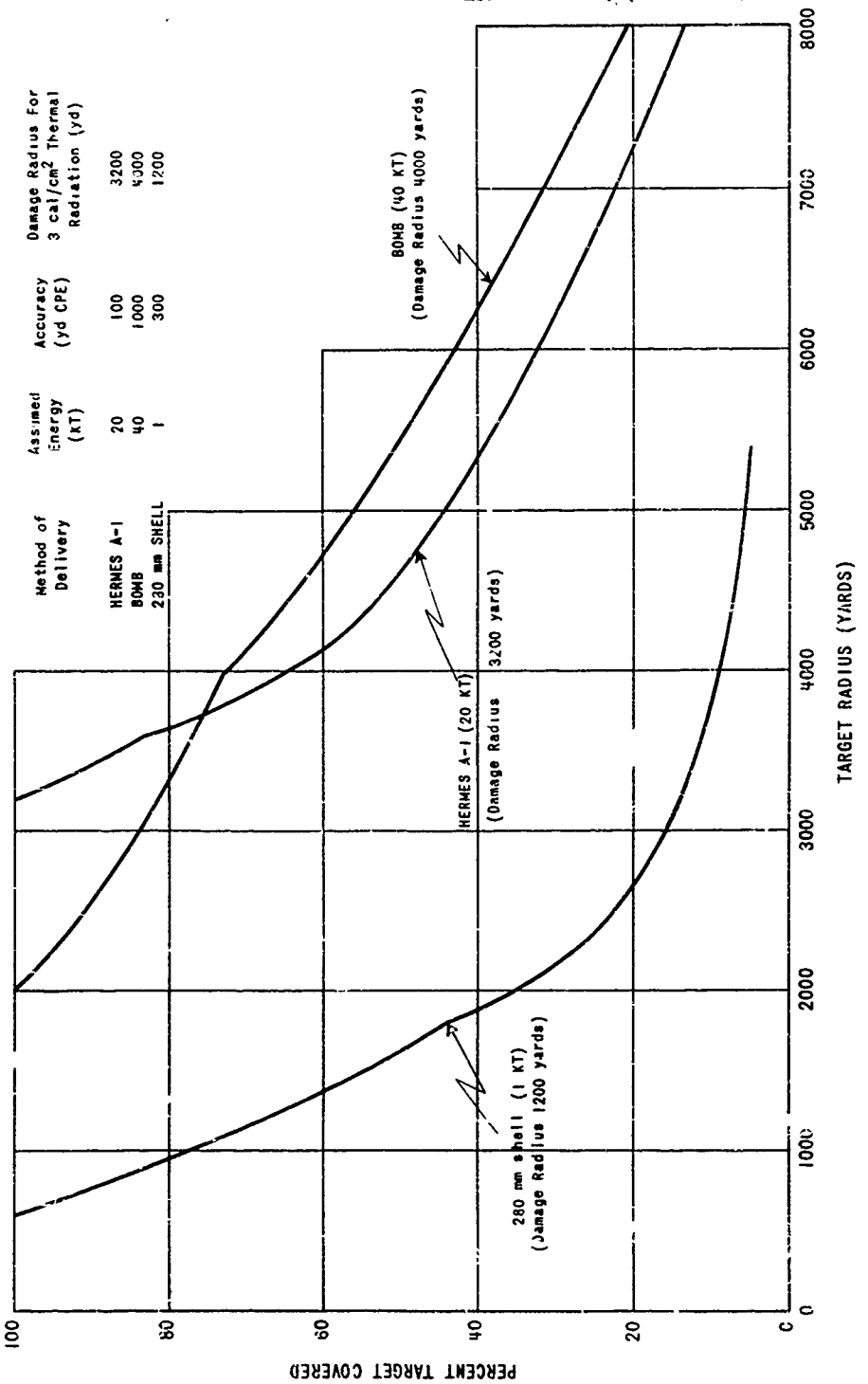

Figure 38.—Percentage of Circular Target Covered with .937 Probability vs. Target Radius

Figure 38.—Percentage of Circular Target Covered with .937 Probability vs. Target Radius

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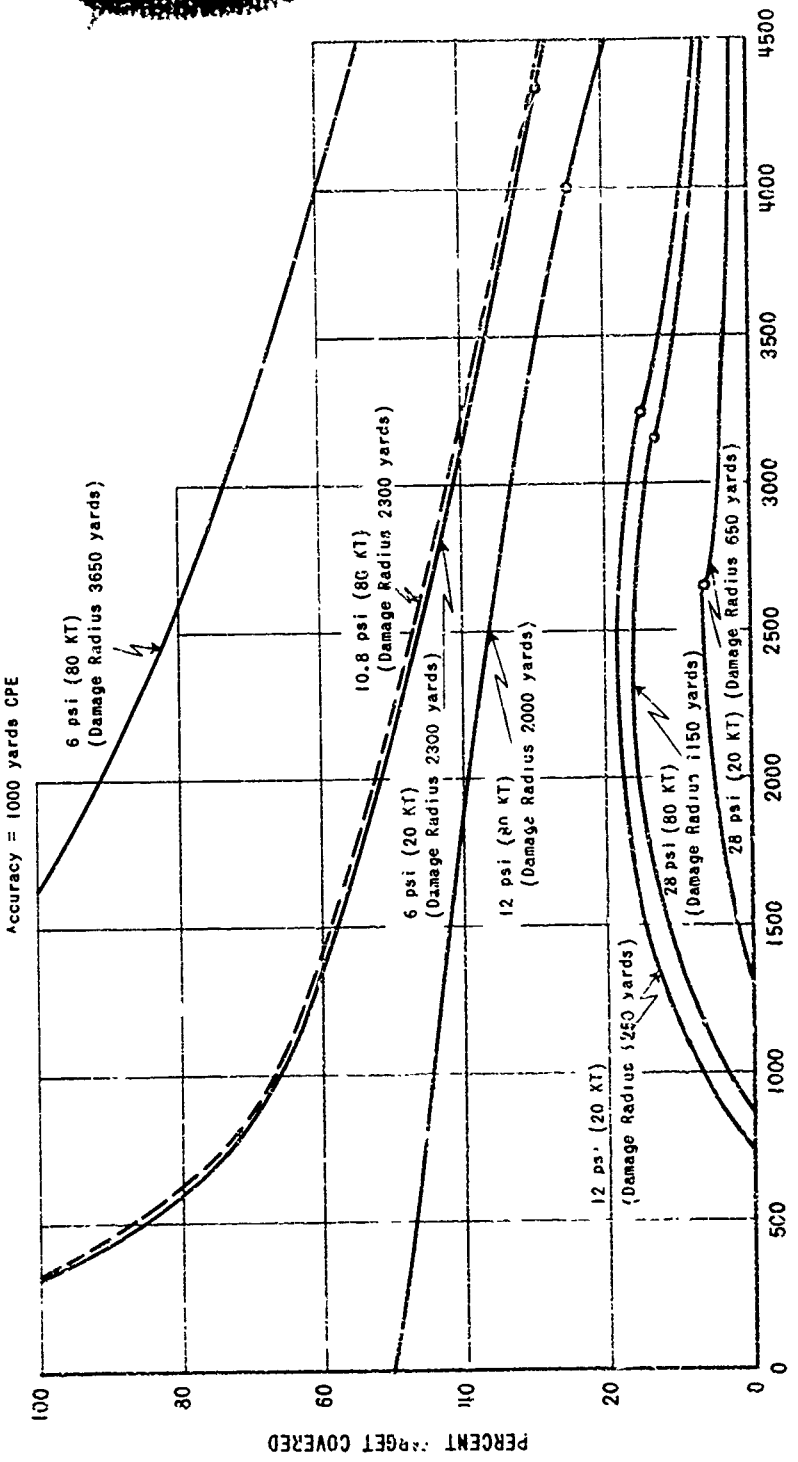

Figure 38.—Percentage of Circular Target Covered with .937 Probability vs. Target Radius (For Various Overpressures)

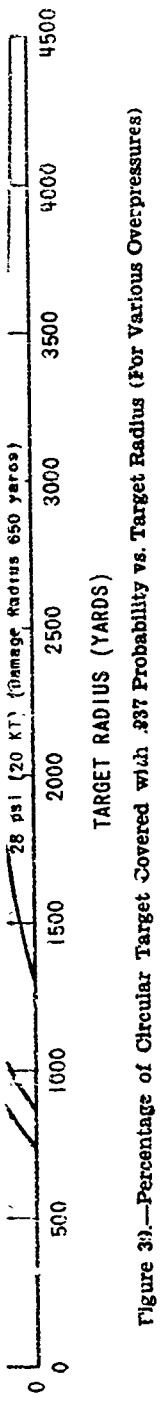

Figure 39.—Percentage of Circular Target Covered with .937 Probability vs. Target Radius (For Various Overpressures)

limit damage equivalent to 12 psi an 80 KT bomb gives at least double the coverage of a 20 KT bomb although for neither is the coverage very good. For 6 psi damage the 80 KT bomb gives only 45 percent coverage for the same radius, and the 20 KT bomb will give 80 percent coverage for targets no larger than 600 yards radius. These are all significantly better results for the 80 KT bomb, and it must be presumed that efforts to increase the burst energy are important.

SYNTHESIS OF WEAPONS SYSTEMS REQUIRED

SELECTION OF ATOMIC WEAPONS

The analysis of the preceding section will now be brought to bear on the problem of selecting the necessary atomic weapons and weapons systems for ground operations. It has not been pretended that the analysis has been either exhaustive or sufficiently analytic to be considered final. Until the necessary mathematical techniques are developed and used, until the complex problem of the effect on ground operations of damages of various kinds which can be produced by atomic weapons are analyzed in detail, many conclusions must be questioned.

Nevertheless, some things are now apparent. From the original list of atomic weapons, Table XL, three weapons should be deleted as a result of the discussion thus far: item 2, 30 KT bomb, because it is obsolete; and item 4, radiological warfare; and item 7, the artillery shell of 1 KT energy. The remainder can be classified as follows:

1. Bombs above 20 KT—air or ground burst;
2. Penetrating bomb—with or without jet, air or ground burst;
3. Guided missile—air or ground burst, or penetrating;
4. Artillery shell—air burst, 20 KT;
5. Superbomb—penetrating bomb or guided missile.

Several questions remain, the answers to which will allow selecting from the preceding list the atomic weapons which may be presumed to be adequate for attacking the various targets of importance to ground operations.

[redacted] Required
[redacted] Safeguards

1. What cannot be done with an a

The group of targets on page 19 is the residual list of targets for whi burst was not suitable, will be co The targets can be grouped as follow

a. Armor (fair target for air bu for ground burst);

b. Tactical air fields, for long time

c. Transportation: bridges, viadu tles, railroad transfer points, tunnels

d. Storage: oil refineries, pipeline voirs and aqueducts;

e. Miscellaneous: submarine pe

This list is an answer to question 1

2. What is the necessity for a pe weapon?

Tactical air fields and submarine targets for which a penetrating weap required. Particularly if an undergrou will cause sufficient damage to den of air fields, the need for a penetrating is demonstrated. Again it is noted th is necessity to determine the effect of ground explosion without delay. It noted that a ground burst or penetr or the other, is best for armor and at time there is a need for good accurac

3. What accuracy requirement de atomic guided missile?

Guided missile accuracy (100 yar lar probable error) is required for tunnels and command posts. Furth sis will probably show situations guided missile accuracy either to friendly personnel and equipment from an extension of the considerati gets of finite size given in the last or because of the overlap problem in tion with the use of more than one weapon per target). Only after analysis can the actual necessity fo pated guided missile accuracy be strated. The problem of how man guided missiles should be stockpiled mediate importance than the nec their development and test.

4. What is the requirement for b accuracy and penetration for a guided

not be done with an air burst?

targets on page 192, which list of targets for which an air suitable, will be considered. be grouped as follows:

ir target for air burst, good st);

r fields, for long time denial;

tion: bridges, viaducts, tres- nsfer points, tunnels;

il refineries, pipelines, reser- ducts;

ous: submarine pens, com- mand posts.

answer to question 1.

he necessity for a penetrating

fields and submarine pens are h a penetrating weapon is re- larly if an underground burst ient damage to deny the use need for a penetrating weapon Again it is noted that there termine the effect of an under- n without delay. It should be ound burst or penetration, one best for armor and at the same need for good accuracy.

racy requirement demands an missile?

e accuracy (100 yards circu- rror) is required for bridges, mand posts. Further analy- y show situations requiring accuracy either to protect nel and equipment (either on of the consideration of tar- ize given in the last chapter, e overlap problem in connec- se of more than one atomic rget). Only after extensive e actual necessity for antici- missile accuracy be demon- roblem of how many atomic should be stockpiled is of less rtance than the necessity for ent and test.

he requirement for *both* great netration for a guided missile?

Command posts and tunnels are the only targets *necessary* to be considered here on the basis that both great accuracy and penetration are required. (By *necessary* it is meant that only targets for which an air burst bomb is inferior should be considered in stating the demand for a different weapon.) From the lack of critical importance of the first target and the questionable necessity for the second target it is concluded that there is *no requirement for a penetrating type guided missile.*

5. How do an artillery shell and a guided missile compare?

Since this study began, it has become known that a 280-mm artillery shell is a possibility. It is estimated that an atomic weapon can be placed on the shell. At an estimated maximum range of 23,000 yards, the estimated accuracy is comparable to that estimated for guided missiles. This is very probably a good weapon for ground operations.

6. What is the importance of the superbomb?

Even though a cursory examination of the importance of the superbomb in ground operations is a necessary preface to a more meaningful analysis, its overwhelming destructiveness and, in general, the implications of its existence are such that one should hesitate to lend even slight emphasis in the wrong direction. What is written here is a qualitative approach to the problem and is presented primarily because even a crude consideration of the requirements for a family of atomic weapons for ground operations must consider the superbomb.

It is very difficult to imagine the significance of producing *very large "holes"* in the battlefield, or the Communications Zone, or even for that matter the Zone of the Interior. These "holes" can be either physical holes or craters in the ground, gaps in communications or transportation, holes in the battlefront where almost no activity survives, actual and total loss of several divisions (perhaps an army) of front line troops including all equipment and supporting facilities. In fact, the result will be nearly total destruction over an area of upward of 100 sq mi, and considerable damage over an area covering several hundreds of sq mi; skin burns can be induced over an area of 1,000 sq mi; very heavy vehicles such as tanks within an area of 25–50 sq mi will be thrown a distance of a quarter of a mile; there will be hurricane force winds of 100–150 mph over more than 500 square miles. In all instances the damage mentioned is at the periphery of the area and increases toward the center of burst. Such effects are so fantastic they may not be interpreted with reference to any known operating techniques of the Army.

In the present pattern of things for army operations, if a superbomb were aimed at enemy armor, friendly troops would have to remain miles away for safety. It would be necessary, in general, to keep friendly dispositions of personnel and equipment some 15 miles away from the center of burst. Even though imagination is inadequate to estimate the various measures and countermeasures which would accompany the use of such a weapon, it may certainly be said that if the superbomb is developed and used by the US or the USSR, the effect on ground operations will be stupendous. The superbomb seems *actually* to be the terrible weapon that the 20 KT atomic bomb was thought to be in the days immediately after Hiroshima and Nagasaki.

FINAL LIST OF ATOMIC WEAPONS REQUIRED

As a result of the considerations in the preceding section, it is now possible to set down the list of atomic weapons needed for ground operations:

1. Bombs above 20 KT—air or ground burst;
2. Penetrating bomb—with or without jets, air or ground burst;
3. Guided missile—air or ground burst;
4. Artillery shell—air or ground burst;
5. Superbomb.

In spite of the considerations which have indicated that a ground burst (ground to treetop levels) is not very necessary, it is included here because it can probably be obtained with a minor modification of the air burst fuzing.

CONCLUSIONS

1. The work represented in this paper is qualitative and, hence, subject to revision as methods which are more analytic in nature

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are applied. Nevertheless, several conclusions can be stated and the necessity for continued work can be defined.

2. Appropriate mathematical formulation can and should be developed for the special problems imposed by the use of atomic weapons.

3. No adequate solution to the general problems studied here can be obtained without a very careful and detailed analysis of complete tactical situations wherein all the components of means available and opposed are represented in sufficient detail to allow all the damage of various kinds to be integrated.

4. Artillery, infantry and tactical air are suitable targets for atomic weapons in that order of suitability. Armor (manned tanks) may be included as a result of current studies.

5. Logistical targets are *not* suitable targets for planned attacks with atomic weapons. Ports may be an exception.

6. The air burst atomic bomb is an excellent weapon for many types of targets of importance to ground operations.

7. Some important targets require a ground or underground explosion.

8. There are several very important targets for which an air burst is not suitable.

9. Underground or underwater bursts are important depending for the former on the actual effect which is not now known, but if predicted effects are correct, the underground burst may be better than the air burst for many targets.

10. A guided missile giving much greater accuracy than present radar bombing accuracy would give greater damage to many types of targets, but not to all.

11. A field artillery shell of 1 KT energy is not as good a weapon as a 20 KT bomb, as concluded from accuracy and damage considerations and aside from considerations of weather and deliverability in general.

12. An 80 KT bomb is much preferred to a 20 KT bomb for various targets.

13. The effect of superbombs on ground operations is enigmatic. Potentially the resultant destruction would be so great as to revolutionize ground operations.

RECOMMENDATIONS

1. The effect of an underground explosion should be determined without delay.

2. An atomic warhead and an appropriate vehicle like Hermes A–1 or Corporal E should be developed for use, if possible, within a year.

3. An atomic warhead for an artillery shell is probably a very good interim weapon for use in ground operations and should be developed without delay.

4. A superbomb should be developed without delay, but work upon such a new development should not interrupt nor interfere with the continued development of fission type atomic weapons.

5. Use of large quantities of atomic weapons in all large scale ground operations should be planned.

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ANNEX 4
ATOMIC WEAPONS IN WESTERN EUROPE

Prepared by
W. L. WHITSO and W. B. COTTRELL

1 January 1950

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RESTRICTED DATA
Atomic Energy Act 1946
Specific Restricted Data Clearance Not Required
Use Military Classification Safeguards

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PROJECT *MAID*

1 January 1950

Annex 4

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RESTRICTED DATA
ATOMIC ENERGY ACT - 1946
SPECIFICALLY RESTRICTED DATA
CLEARANCE NOT REQUIRED
FOR MILITARY CLASSIFICATION SAFEGUARDS

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ATOMIC WEAPONS IN WESTERN EUROPE

SUMMARY

PROBLEM

The problem is to give a preliminary estimate of the effectiveness of atomic weapons on the defense of western Europe, and to outline some of the problems which must be solved before a complete analysis can be made.

FACTS AND ASSUMPTIONS

The decision to use an atomic weapon against a particular target is complicated. Eleven factors are listed which must be taken into consideration.

For the analysis in this paper a field army is assumed to be composed of the following:

1. Forces—Infantry, armor, artillery, tactical air;

2. Logistics—Transportation, storage.

Two principles are stated:

1. Tactical planning in advance of battle cannot evaluate the importance of targets of opportunity.

2. Defense against atomic weapons requires greater dispersal or more protection of personnel and facilities.

The following possible schedule for development of atomic weapons is set up:

1. 1950. An air burst atomic bomb with energy somewhat greater than 20 KT is the only weapon existing. Efforts to develop a penetrating type are proceeding but the effects of penetration are not known.

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2. 1951. It is possible to have an air burst weapon by this date having greater energies. It could be possible by this time to develop jets for a penetrating type weapon in the event jets are necessary.

3. 1952. A warhead can be developed by this time for use on a Corporal E or Hermes A-1 guided missile, both of which could be ready by that time. The range of such missiles is about 80 miles and estimated accuracy 1,000 feet cpe for Corporal E and 300 feet cpe for Hermes A-1.

4 1955. Guided missiles with longer range and greater accuracy than those given in paragraph 3 will be developed by this time. Estimated accuracy (200 feet cpe) is such that if necessary small targets such as bridges could be destroyed.

5. 1955-1960. In this period it should be possible to round out the development of an adequate family of atomic weapons for use in ground operations if the military requirement is set up immediately.

It is assumed that for the next two years or so the US will have significant superiority over the USSR in atomic weapons.

It is assumed that by 1952 the US will have 850 atomic weapons and the USSR 100. These figures are extracted from guesses in the US News magazine and are used merely to allow certain arguments to be presented in concrete form and are not an attempt on the part of the authors to guess the size of the stockpile.

It is assumed that for the period beginning a short time after 1952, because of the difficulties in determining the number types and effects of atomic weapons manufactured by the USSR, it is impossible to predict in any simple way the effect of atomic weapons used either by the US or the Soviets. Such analysis can, however, result from comprehensive studies which can be completed in the near future.

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DISCUSSION

A superficial analysis of the vulnerability of infantry, artillery armor, tactical air, and logistics is given. Even though superficial, however, the analysis is more meaningful in determining the general vulnerability of ground forces than analyses which are limited to a listing and assessment of vulnerability of the many separate targets which must be considered, e. g., aircraft, infantry, pipelines, and tunnels.

CONCLUSIONS

The vulnerability of infantry varies greatly depending on the type and history of the particular engagement. A detailes study of maneuvering infantry is possible and will be necessary before meaningful conclusions can be made. Certainly three to five atomic bombs aimed properly and at the right time should produce enough personnel casualties to knock out a division in most tactical situations.

Armor (manned tanks) may be a good target for a ground burst but only a fair target for an air burst atomic bomb. Vulnerability of manned tanks to atomic weapon attack is currently under investigation.

The vulnerability of artillery reflects the fact that effective artillery fire is the end product of a necessary and well integrated chain of events. Even though artillery pieces are not grossly damaged, skilled personnel, precise equipment, and intricate communications systems are quite vulnerable to an air burst atomic weapon. Here again there is need for a much more detailed study than has been possible.

Soviet logistics present individual targets which are, in general, small and numerous, and certain vital parts of the system are more vulnerable to other conventional weapons. The greatest difficulty in evaluation is lack of intelligence information. It is judged that Soviet logistics is not a good planned target for atomic weapons.

US logistics is more susceptible than that of the USSR, especially if operations are on the Eurasian continent, where points become vital to the logistic

[redacted]

system. However, the probability is that the US logistical system can be made sufficiently invulnerable.

Ground warfare from 1950 on will be greatly influenced by the use of atomic weapons.

Atomic weapons can have a decisive effect on the defense of western Europe, and from 1952 on there is high probability of their use in large quantity by both US and Soviet in support of their ground operations.

A detailed and exhaustive study must be made of the effects of atomic weapons on the tactics of field armies.

A special study should be made of the effect of superbombs on ground operations.

RECOMMENDATIONS

Studies should be initiated wherever possible in the army to investigate in great detail the necessary changes in the strategy and tactics of ground operations which must anticipate the use of atomic weapons.

Plans for the defense of western Europe should consider and require the use of large quantities of atomic weapons in support of ground operations.

Consideration should be giventо using at least 500 atomic weapons in support of Allied ground operations in the defense of western Europe.

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Appendix B

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ATOMIC WEAPONS IN WESTERN EUROPE

INTRODUCTION

There is a possibility that atomic weapons may be used in a battle for western Europe within the next few years. Even though rough, a current estimate of the value of attainable atomic weapons used in support of ground operations is strictly necessary as a guide to the development of these weapons and as a preface to military planning for the defense of western Europe.

It is realized that any complete evaluation of the importance of atomic weapons in support of ground operations must take into consideration the over-all strategy as well as to exhibit in detail the relationship between atomic weapons and all other weapons which are to be employed in the various anticipated field operations. Even though such an evaluation is not now possible, several important phases of operations may be analyzed in sufficient detail to define some essential limitations on the utility of atomic weapons and, more importantly, to demonstrate that they may in some respects be decisive in determining the progress of ground operations.

A decision to use atomic weapons against a particular target and for a particular purpose, whether the decision be for over-all planning or an actual decision of the field commander, must include many factors. At least, in some respects, a decision to use an atomic weapon is more involved and of more consequence than a decision to use any other weapon that has been available for use in ground operations at any time in history.

The following list is not supposed to be exhaustive. It is, however, indicative of the complexity of the problems involved in deciding to use an atomic weapon.

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Factors Involved in a Decision to Employ an Atomic Weapon Against a Particular Target:

1. Size and nature of target;

2. Importance of the target in the operation;

3. Effect desired, degree and time history of;

4. Availability of atomic weapons;

5. Delivery: means, accuracy, enemy countermasures;

6. Danger to friendly troops and equipment;

7. Coordination with scheme of maneuver;

8. Expected enemy reaction;

9. Comparison with other means of neutralizing targets;

10. Comparison of this attack with other possible current or future use of atomic weapons;

11. Political considerations.

For the purpose of a preliminary evaluation of the importance of atomic weapons in support of ground operations, it will be assumed that a field army may be represented by the following:

1. Forces—

   a. Infantry,

   b. Armor,

   c. Artillery,

   d. Tactical Air.

2. Logistics—

   a. Transportation,

   b. Storage.

[redacted]

[redacted]

Considering these elements of force and logistics as targets for atomic weapons, a preliminary analysis will be made in this paper to indicate the vulnerability of each target. Where significant differences exist, the Soviet situation will be considered separately from that of the US and its Allies. Separate analyses will also be made for 1950, 1952, 1955, and 1955-1960, wherein the number of atomic weapons and weapons systems available at each time will be assumed.

Two important principles will now be stated:

1. Tactical planning in advance of the battle cannot evaluate the importance of targets of opportunity. Although it is difficult categorically to define a target of opportunity, it is sufficient for the present to mention some targets. A fleeting target set up momentarily in the course of events is certainly such a target. However, infantry maneuvering in the field need not be classified as a target of opportunity if it is not necessary to know their location very accurately. If it is a sufficiently permanent target and if intelligence of its existence is available for planning purposes, then it would not be so classified. If, however, the existence and description of a depot or dump becomes known during the battle, it probably should be considered a target of opportunity. The suggestion in stating the above principle is not that targets of opportunity are unimportant; they may even be decisive. Planning, however, cannot reliably anticipate their importance and this paper will not be concerned with such targets.

2. Defense against atomic weapons requires dispersal of or more protection of personnel and facilities. This doctrine for defense against atomic weapons has been established for some years. Two questions must always be answered: What dispersal is necessary to reduce the calculated risk acceptably? How much and what kind of dispersal if possible without reducing the efficiency of the organization? The doctrine of dispersal is dangerous in application unless it can be quantified with respect to calculated risk and loss in efficiency.

VULNERABILITY OF A FIELD BODY TO ATOMIC WEAPONS

As a preface to an analysis which shows the relative vulnerability of the various targets presented by a field

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army, a discussion of each of the major components of the army is given. This material is reproduced in Annex 3. Because it is immediately pertinent to the discussion which follows, it should be read now by those who have not already read Annex 3.

SYNTHESIS OF VULNERABILITY OF GROUND FORCES TO ATOMIC WEAPONS

The arguments appearing in Annex 3 apply equally to both the USSR and the US, except for the qualifications already noted. Therefore, applicable to both the US and the Soviet military situations, the following is a list of the components of a field army in the order or general suitability for attack with atomic weapons:

1. Artillery,

2. Infantry,

3. Tactical air,

4. Storage,

5. Transportation,

6. Armor (preliminary data from current studies may raise the position of this target).

Much detailed analysis is necessary to substantiate the conclusion here that artillery is vulnerable to an air burst. In particular, methods of rendering artillery less vulnerable than it is at present must be scrutinized. Until possible remedial measures are applied, planning should assume that atomic bombs used against artillery will have a great effect on ground operations.

In general, it is considered that there is less profit in using atomic weapons on infantry than on artillery. The detailed analyses which will be made in the near future will demonstrate definitely whether or not atomic weapons should be used against infantry. At the present time, a planned attack specifically against infantry as a target should be considered of undetermined value.

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Tactical air is listed here principally because of the overriding importance of air supremacy. Since logistics, is, in general, not susceptible to attack by atomic weapons, conventional means such as tactical aircraft with TNT bombs, rockets, and guns are required The personnel, equipment, and planes associated with air fields are vulnerable to an air burst atomic bomb, but it is again emphasized here that if possible a penetrating type bomb should be developed which will either weaken the subgrade of an airstrip or produce an earth movement which will destroy the runways.

A planned attack on logistics, either transportation or storage, or armor, should not be predicated on the use of atomic weapons. Logistics are, in general, not good targets for atomic weapons. Again it is noted that in all probability many atomic bombs can and will be used against these targets as targets of opportunity. A plan of battle, however, may not be devised which demands the use of atomic weapons to knock out either logistics or armor.

NEW WEAPONS

The fact that many possibilities are known to the US for new atomic weapons demands considerable caution in the assumption that the US or its Allies can predict what type of atomic weapons the Soviets will develop. Much more can be stated about what type of atomic weapons the US can and ought to develop for support of ground operations. In this section the possibilities for new weapons which are pertinent are repeated.

FORECAST SCHEDULE FOR DEVELOPMENT OF ATOMIC WEAPONS

1950:

1. Atomic bomb (more than 20 KT);

2. Penetrating atomic bomb.

The most important unknown factor in determining the capabilities of atomic weapons for 1950 is the effect of the penetrating type atomic bomb. Depending on the ground structure, a sufficient penetration may be possible, by dropping from an airplane at high altitude,

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to either weaken the substructure or produce a base surge. Again, great emphasis must be placed on the necessity for determining the effectiveness of a penetrating weapon since, for example, an air burst atomic bomb will not deny the use of an airstrip for very long.

1951:

1. Atomic bomb (improved type);

2. Penetrating type atomic bomb with jet assists to aid penetration.

For some purposes the successful development of an improved higher energy air bomb will be very important but, in general, no great assistance is anticipated from it in connection with ground operations. If by this time it has been demonstrated that a penetrating type weapon will not produce the necessary effect because of insufficient penetration for 1951, it would be possible to make other attempts to obtain the necessary penetration as, for example, by using jets. The possibilities for atomic weapons in 1951 are substantially the same as for 1950 with the exception, of course, of a greater number of atomic bombs and with the very important possibility that a penetrating type weapon may be determined useful in ground operations.

1952:

1. Modified atomic warhead for Corporal E or Hermes A-1 guided missiles;

2. Modified weapon for 280mm artillery shell.

The greatest single assistance to ground operations by way of atomic weapons development is in the development of an atomic warhead for a guided missile. The limitations on use in ground operations imposed by present inaccuracies of high level bombing have already been discussed. According to present assumptions, an atomic warhead on a Corporal E missile with guidance appropriate to attain an estimated 1,000 feet circular probable error is possible. It is also predicted that a guidance system can be developed for Hermes A-1 which will have an accuracy of 300 feet circular probable error. Because of the restricted range of Corporal E or

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Hermes A-1 (approximately 80 miles), this weapons system could not be used, of course, to attack tactical air fields. However, its possible use against artillery and infantry is very important. The necessity for accuracy is very great, particularly in the use of an atomic bomb against opposing infantry in order that no casualties be inflicted on friendly infantry.

1955:

1. Modified atomic warhead for Hermes A-3 guided missile.

Hermes A-3 will have greater range than Corporal E (approximately 150 miles) and will be considerably more accurate (estimated 200 feet circular probable error). It is difficult at the moment to estimate the advantage of the additional range or the necessity for an accuracy of the order indicated. It must certainly be true that both are to some extent desirable. Within a short time it should be possible to judge the necessity for greater accuracy on the basis of detailed analyses of the use of atomic weapons against artillery and infantry. With a Hermes A-3 guided missile there is a much greater possibility of destroying a bridge target for which it has already been stated that a radius of destruction for a 20 KT weapon is estimated to be approximately 200 feet.

EFFECT ON GROUND OPERATIONS

At the present time it can be assumed that the US has many more atomic bombs than the Soviets. In a few years, it is very important that the US have a much larger atomic stockpile than the Soviets, but is must be assumed that the USSR will have many atomic weapons. The US News magazine recently guessed that by 1952 the US would have 850 atomic bombs and the USSR would have 100. Without giving any credibility to these guesses, one may still use the figures in order to talk about concrete examples. In the next two years it can be assumed that any atomic weapons used in support of Allied ground operations would far outnumber those which might be used for similar purposes by the USSR. This is the only period of time during which it may be assumed that

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the Allies would use a markedly greater number of atomic weapons in all circumstances. By this is meant that by 1952 the US might designate any number of atomic weapons from zero to 850 for support of ground operations and the Soviets might plan to use any number up to 100 for the same purpose. It is important to determine, for example, the effect in 1952 of several hundred atomic weapons used by the Allies in support of their ground operations as against none for a similar purpose by the Soviets. The other extreme is equally meaningful—that the Soviets in 1952 might use 100 in their own ground operations while the Allies were using none for the same purpose—while reality must be somewhere between.

What is the anticipated effect on ground operations of any given number of atomic weapons? Again, it is acknowledged that a complete analysis must include all weapons, atomic and others. However, in considering the possibilities for exploiting atomic weapons, it is profitable to determine the effectiveness of a strategy centered around the use of large quantities of atomic weapons in support of ground operations.

The Rhine River is approximately 500 miles long from Basle to the North Sea at Rotterdam. Five hundred air burst atomic bombs accurately dropped with points of impact two miles apart could produce almost total destruction of military strength the full length of the river in a band four miles wide. There is no possibility of a procedure of this sort. More meaningful is that with 500 bombs 10 percent of the river front could be attacked covering virtually all territory to a depth of 40 miles. These are, of course, schematic representations but they do support a general impression that 500 atomic bombs would effectively support a defense of the Rhine.

A more realistic picture can be obtained considering popular estimates of the mass strength of Soviet attempts to advance from east to west across Europe. Several planning agencies apparently concur in estimates that the Soviets will use a total of 40 divisions in four spearheads crossing the Rhine. A total of 500 atomic bombs averages more than 10 per division. Even a cursory examination suggests that this is many more bombs than would actually be required to knock out one division (doctrine in the US Army places the division

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lines for offensive operations 3,000 to 5,000 yards apart or approximately two and one-half miles). Then if it is reasonable to assume that 500 atomic bombs would be decisive in conjunction with conventional means to hold a line at the Rhine, the more pertinent question is: What is the effect of any number smaller than 500?

On the basis of current Soviet and Allied field practices, one well-timed and well-placed atomic bomb will, because of its combined effect on artillery, infantry, and logistics, reduce the military effectiveness of a division of infantry to a point where the division could not support an offensive and would be extremely vulnerable on the defensive. On this basis 100 atomic bombs must be assumed to have an enormous effect on the field armies of either the Allies or the Soviets.

The following possibilities are now significant for 1952 when, as previously, we assume the US will have 850 bombs and USSR 100:

EFFECT OF BOMBS USED IN GROUND OPERATIONS ON HOLDING A LINE AT THE RHINE

US	USSR	Remarks
1. 500 or more . . .	0	Decisive for US.
2. 100 to 850. . . .	100	Undetermined, depends on ponderance of other means.
3. 0	100	Decisive for USSR.

With regard to a hot war starting three or four years or more hence, at the present time it is impossible to make any simple estimate of the effect of the use of atomic weapons in quantity by either the Allies or Soviets in support of their ground operations. The following are reasons:

1. Information on USSR stockpile and production rate of atomic materials will not be sufficiently precise or reliable to give more than a general estimate of quantity of atomic weapons.

2. There are many possibilities of types of weapons including energy, method of delivery, accuracy, et cetera.

SECRET

RESTRICTED DATA
ATOMIC ENERGY ACT - 1946
SPECIFIC RESTRICTED DATA
CLEARANCE NOT REQUIRED
USE MILITARY CLASSIFICATION SAFEGUARDS

RECOMMENDATIONS

1. Studies should be initiated wherever possible in the Army to intensively and thoroughly study the necessary changes in strategy and tactics in army operations which must anticipate the use of atomic weapons.

2. Plans for the defense of western Europe should consider and require the use of large quantities of atomic weapons in support of ground operations.

3. Consideration should be given to the use of at least 500 atomic weapons in support of Allies ground operations in the defense of western Europe.

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